FIRST BOOK OF BOTANY

BY

ELIZA A. YOUMANS

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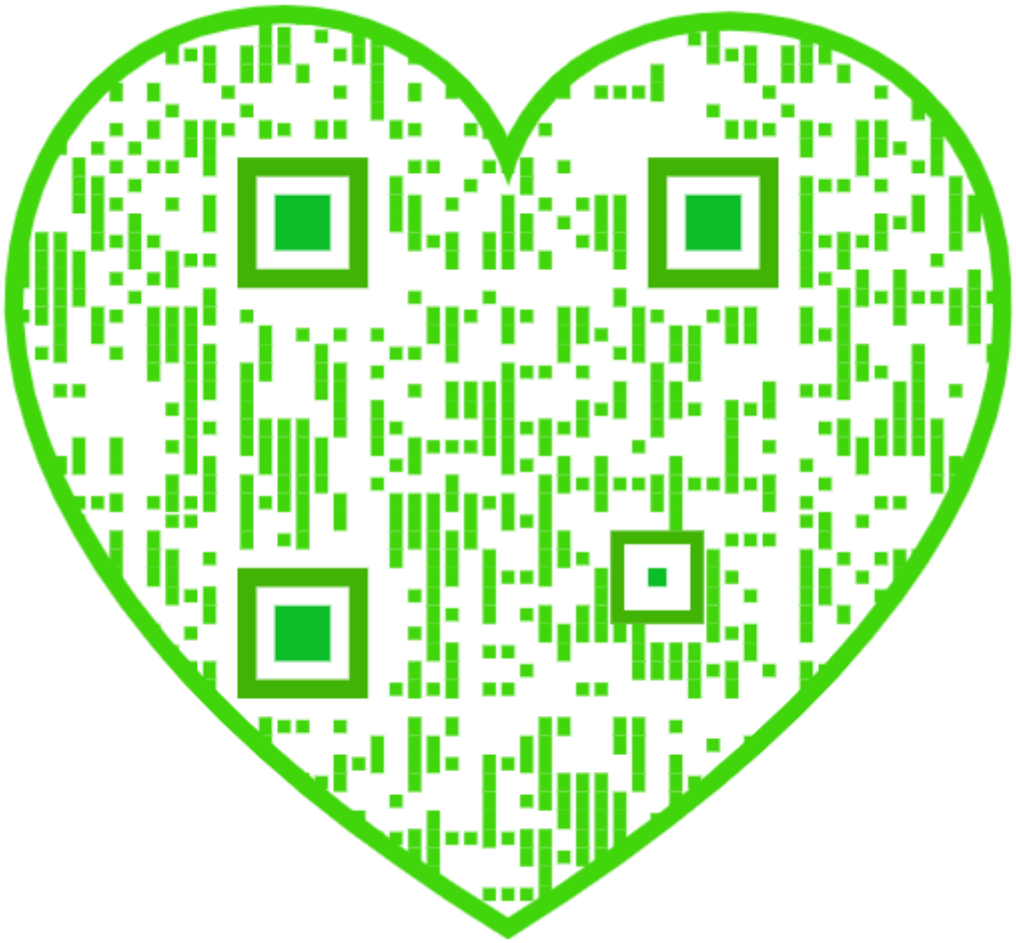

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THE

FIRST BOOK OF BOTANY.

A PRACTICAL GUIDE IN SELF-TEACHING.

DESIGNED TO CULTIVATE THE OBSERVING AND REASONING POWERS OF CHILDREN.

BY

ELIZA A. YOUMANS.

NEW EDITION, THOROUGHLY REVISED.

NEW YORK . CINCINNATI . CHICAGO

AMERICAN BOOK COMPANY.

[1898]

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PREFACE.

This little book has a twofold claim upon those concerned in the work of education.

In the first place, it introduces the beginner to the study of Botany in the only way it can be properly done — by the direct observation of vegetable forms. The pupil is told very little, and from the beginning, throughout, he is sent to the plant to get his knowledge of the plant. The book is designed to help him in this work, never to supersede it. Instead of memorizing the statements of others, he studies the things themselves. The true basis of a knowledge of Botany is that familiarity with the actual characters of plants, which can only be obtained by direct and habitual inspection of them. The beginner should therefore commence with the actual specimens, and learn to distinguish those external characters which lie open to observation; the knowledge of which leads naturally to that arrangement by related attributes which constitutes classification.

But the present book has a still stronger claim to attention; it develops a new method of study which is designed to correct that which is confessedly the deepest defect of our current education. This defect is the almost total lack of any systematic cultivation of the observing powers. Although all real knowledge begins in attention to *things*, and consists in the discrimination and comparison of the likenesses and differences among objects; yet, strange to say, in our vaunted system of instruction there is no provision for the regular training of the perceptive faculties. That which should be first and fundamental is hardly attended to at all. We train in mathematics, and cram the contents of books, but do little to exercise the mind upon the realities of Nature, or to make it alert, sensitive, and intelligent, in respect to the order of the surrounding world.

Something, indeed, has been done in the way of object-teaching, although but little that is satisfactory. These exercises are notoriously loose, desultory, incoherent, and superficial, and hardly deserve the name of mental training. What is wanted is, that object-studies shall become more close and methodic, and that the observations shall be wrought into connected and organized knowledge. It is the merit of Botany that, beyond all other studies, it is suited to the attainment of this end. Plants furnish abundant and ever-varying materials for observation. The element-

ary facts of Botany are so simple that their study can be commenced in early childhood, and so numerous as to sustain a prolonged course of observation. From the most rudimentary facts the pupil may proceed gradually to the more complex; from the concrete to the abstract; from observation to the truths resting upon observation, in a natural order of ascent, as required by the laws of mental growth. The means are thus furnished for organizing object-teaching into a systematic method, so that it may be pursued continuously through a course of successively higher and more comprehensive exercises. Carried out in this way, Botany is capable of doing for the observing powers of the mind what mathematics does for its reasoning powers.

Moreover, accuracy of observation requires accuracy of description; precision of thought implies precision in the use of language. Here, again, Botany has superior advantages. Its vocabulary is more copious, precise, and well settled than that of any other of the natural sciences; it is thus unrivaled in the scope it offers for the cultivation of the descriptive powers.

On purely mental grounds, therefore, and as a means of attaining the most needed of educational reforms, Botany has a claim to be admitted as a fourth fundamental branch of common-school studies; and the hope of contributing something to this end

has been the author's main incitement in the preparation of this rudimentary work.

It is needful here to state that the method of instruction developed in these pages is no mere educational novelty; it was tested and its fitness for the end proposed shown in practice by Prof. J. S. Henslow, of Cambridge, England. My attention was first drawn to it as I was looking about in the educational department of the South Kensington Museum, in London. In a show-case of botanical specimens, I noticed some slates covered with childish handwriting, which proved to be illustrations of a method of teaching Botany to the young. They were furnished by Prof. Henslow for the International Exhibition of 1851. He died without publishing his method, but not without having subjected it to thorough practical trial. He had gathered together a class of poor country children, in the parish where he officiated as clergyman, and taught them Botany by a plan similar to the present, though less simplified. The results of this experiment have been given to the public by Dr. J. D. Hooker, Superintendent of the Botanical Gardens at Kew, who was summoned to give evidence upon the subject before a Parliamentary Commission on Education.

The following interesting passages from his testimony will give an idea of Prof. Henslow's method of proceeding and its results:

Question. Have you ever turned your attention at all to the possibility of teaching Botany to boys in classes at school?

Answer. I have thought that it might be done very easily; that this deficiency might be easily remedied.

Q. What are your ideas on the subject?

A. My own ideas are chiefly drawn from the experience of my father-in-law, the late Prof. Henslow, Professor of Botany at Cambridge. He introduced Botany into one of the lowest possible class of schools—that of village laborers' children in a remote part of Suffolk.

Q. Perhaps you will have the goodness to tell us the system he pursued?

A. It was an entirely voluntary system. He offered to enroll the school-children in a class to be taught Botany once a week. The number of children in the class was limited, I think, to forty-two. As his parish contained only one thousand inhabitants, there never were, I suppose, the full forty-two children in the class; their ages varied from about eight years old to about fourteen or fifteen. The class mostly consisted of girls. . . . He required that, before they were enrolled in the class, they should be able to spell a few elementary botanical terms, including some of the most difficult to spell, and those that were the most essential to begin with. Those who brought proof that they could do this were put into the third class; then they were taught once a week, by himself generally, for an hour or an hour and a half, sometimes for two hours (for they were exceedingly fond of it).

Q. Did he use to take them out in the country, or was it simply lessons in the school?

A. He left them to collect for themselves; but he visited his parish daily, when the children used to come up to him, and bring the plants they had collected; so that the lessons went on all the week round. There was only one day in the week on which definite instruction was given to the class; but on Sunday afternoon he used to allow the senior class, and those who got marks at the examinations, to attend at his house. . . .

Q. Did he find any difficulty in teaching this subject in class?

A. None whatever; less than he would have had in dealing with almost any other subject.

Q. Do you know in what way he taught it? did he illustrate it?

A. Invariably; he made it practical. He made it an objective study. The children were taught to know the plants, and to pull them to pieces; to give their proper names to the parts; to indicate the relations of the parts to one another; and to find out the relation of one plant to another by the knowledge thus obtained.

Q. They were children, you say, generally from eight to twelve?

A. Yes, and up to fourteen.

Q. And they learned it readily?

A. Readily and voluntarily, entirely.

Q. And were interested it?

A. Extremely interested in it. They were exceedingly fond of it.

Q. Do you happen to know whether Prof. Henslow thought that the study of Botany developed the faculties of the mind —that it taught these children to think? and do you know whether he perceived any improvement in their mental faculties from that?

A. Yes; he used to think it was the most important agent that could be employed for cultivating their faculties of observation, and for strengthening their reasoning powers.

Q. He really thought that he had arrived at a practical result?

A. Undoubtedly; and so did every one who visited the school or the parish.

Q. They were children of quite the lower class?

A. The laboring agricultural class.

Q. And in other branches receiving the most elementary instruction?

A. Yes.

Q. And Prof. Henslow thought that their minds were more developed; that they were become more reasoning beings, from having this study superadded to the others?

A. Most decidedly. It was also the opinion of some of the inspectors of schools, who came to visit him, that such children were in general more intelligent than those of other parishes; and they attribute the difference to their observant and reasoning faculties being thus developed. . . .

Q. So that the intellectual success of this objective study was beyond question?

A. Beyond question. . . . In conducting the examinations of medical men for the army, which I have now conducted for several years, and those for the East India Company's service, which I have conducted for, I think, seven years, the questions which I am in the habit of putting, and which are *not* answered by the majority of the candidates, are what would have been answered by the children in Prof. Henslow's village-school. I believe the chief reason to be, that these students' observing faculties, as children, had never been trained—such faculties having lain dormant with those who naturally possessed them in a high degree; and having never been developed, by training, in those who possessed them in a low degree. In most medical schools, the whole sum and substance of botanical science is crammed into a few weeks of lectures, and the men leave the class without having acquired an accurate knowledge of the merest elements of the science. . . .

The printed form or *schedule* contrived by Prof. Henslow, and used in these classes, applied only to the flower, the most complex part of the plant, and the attention of children was directed by it chiefly to those features upon which orders depend in classification. But, instead of confining its use to the study of the flower, it seemed to me to be equally useful in the whole course of Descriptive Botany. I accordingly prepared a simplified series of exercises on this plan, and used them to guide some little children in

studying the plants of the neighborhood; and the experiment was regarded by those who witnessed it as so successful, that a book embodying the course of study was thought desirable.

After a year's trial with this method of study, in many schools of all grades and by private students, it has been approved with remarkable unanimity and earnestness. We have, therefore, now added several chapters concerning the seed, germination, buds, the aspect of woody plants, etc. The descriptions required by these objects will be more full and general, but the plan of describing only the results of actual observations is still adhered to. Questions are asked, but no answers are given; these are to be found by direct inspection of the objects. Some simple experiments for children are introduced, and their attention is directed to the changes which take place in the different parts of the plants.

Only those observations have been selected which can be made with the naked eye. But in "The Second Book of Botany" the plan of schedule-study is carried out, and provision made for more close and extended observations requiring the help of magnifying-glasses.

Attempts have been made to teach classes by the schedule method of this work, giving the children only blackboard-lessons for guidance instead of the

book; but all such attempts will be futile. For the very essence of this method is that the pupil must himself find out what he wants to know, and the repetition of observations, their comparison, and verification in determining characters, make it indispensable that book and plant should go together. Only as a manual of practice in the hands of the learner can the present book subserve the purpose for which it was prepared.

In the preparation of the present cheaper edition of "The First Book of Botany," while its essential plan has been in no wise altered, several changes have been made. Some of the larger and less important illustrations have been omitted, and a few others substituted; the observations upon flowers have been extended, and slight additions made to the text; while, by resetting, the whole matter has been brought within smaller compass.

SUGGESTIONS TO TEACHERS.

The method to be pursued by the aid of this book is the following: The child, first of all, collects some plants—almost any will answer in the start. The roots, stems, and leaves of plants, it is assumed, are already known. But they are made up of parts that vary in form and structure in different species. The object of the learner is to find out these parts, to learn their names and the names of their variations, so as to be able to describe them.

In the First Exercise, for example, he finds the parts of leaves shown by pictures, along with the names by which they are known. He now looks at his specimens, and *finds the real things* which the pictures and the words represent. When a few of the parts are learned he commences the practice of *writing down* what he observes. For this purpose a form, or *schedule*, is used, containing questions which indicate what he is to search for. Models of these schedules are given, in which a pictured example is described. Children can make their own schedules as soon as they have learned to print. At each new exercise he carefully observes his specimens and writes down what he finds. Having done this, he pins the specimen to the paper describing it, and brings all his work to the teacher as the report of his observation and judgment in the several cases.

This operation is constantly repeated upon varying forms, and slowly extended by the addition of new characters. He thus goes on discovering new parts, and learning their names—noting the variations of these parts, and finding the names of these variations. The schedules guide him forward in the right

direction, and hold him steadily to the essential work of exercising his faculties upon the living objects before him. In every fresh collection of plants, new parts and new relations will solicit the attention, and will have to be observed, compared, and recorded. The names of plants, the parts of which are pictured and described in this book, are not given. Many of them are mere diagrams or outlines. Their purpose is to enable the pupil to form clear ideas of what he is to look for in living plants; and they are of no other possible account. The ability to classify and name the plants of a region is one of the final results of this study, and curiosity about their names before their botanical characters are known need not be encouraged. The object is, by constant practice and repetition of observations upon a great variety of plants, to train the pupil to find out the characters of any that come in his way, and make full and accurate descriptions of them.

An acquaintance with botany on the part of the teacher, although desirable, is not indispensable in using these exercises. Any teacher or parent *who is willing to take the necessary pains* can conduct the children through them without difficulty; and if they will become *fellow-students* with them, all the better. The child is not to be *taught*, but is to instruct himself. The very essence of the plan is, that he is to *make his own way*, and rely on nobody else; it is intended for self-development. Mistakes will, of course, be made; but the whole method is *self-correcting*, and the pupil, as he goes forward, will be constantly rectifying his past errors. The object is less to get perfect results at first than to get the pupil's opinion upon the basis of his own observations.

Children can begin to study plants successfully by this method at six or seven years of age, or as soon as they can write. But close observations should not be required from young beginners, nor the exercises be prolonged to weariness. The transition from the unconscious and spontaneous observations of children to conscious observation with a definite purpose should be gradual, beginning and continuing for some time with the easiest exercises upon the most simple and obvious characters.

HENSLOW'S BOTANICAL CHARTS.

In the study of plants, when the parts looked for are complex or minute, it is a great help to the pupil to form beforehand a clear idea of what he is to look for. The illustrations of the book help him in this way, and teachers often prepare large colored diagrams for the same purpose. More fully to meet this need of schools and students, one of the last labors of Prof. Henslow's life was to prepare a set of botanical charts. There was, perhaps, no other living man so competent to the task, as his thorough knowledge of the science, his experience as a lecturer to the Cambridge students when he was professor in that university, and his subsequent teaching of the parish children at Hitcham, qualified him to meet the wants of all grades of learners. He prepared a series of nine large sheets, and, as their publication was expensive, it was undertaken by the Science and Art Department of the English Educational Council. "Henslow's Botanical Diagrams" have a high reputation for their scientific accuracy, their completeness of illustration, their judicious selection of typical specimens, and their skillful arrangement for the purpose of education.

As nothing of the kind had been done in this country, and as Henslow's series when imported is costly; and, especially as they are a most valuable help to the schedule method of teaching botany, I was desirous that the pupils of our schools in their efforts at self-teaching should as far as possible have the advantage of their use. The publishers of this book accordingly incurred the very considerable expense of preparing a revised edition of the English charts. This revision and reissue were the more necessary, as the foreign edition is compressed into

so small a space that the figures often overlap, producing an indistinct and confused effect. The American edition consists of six large charts, and the pictures are spread over twice the original area, giving much greater distinctness and a very attractive aspect to the series. Several American plants have been substituted for the English species that are not found in this country, and illustrations of the classes of flowerless plants have been added, for which Prof. Henslow did not seem to find room.

In the plan of the charts, the plant is first represented of its natural size and colors; then a magnified section of one of its flowers is given, showing the relations of the parts to each other. Separate magnified views of the different floral organs, exhibiting all the botanical characters that belong to the group of which it is a type, are also represented. The charts contain nearly five hundred figures colored to the life, which represent twenty-four orders and more than forty species of plants, showing a great variety of forms and structures of leaf, stem, root, inflorescence, flower, fruit, and seed, with numerous incidental characters peculiar to limited groups. All these are so presented as to be readily compared and contrasted with each other.

The charts are not designed to supersede the study of plants, but only to facilitate it. Their office is the same as the illustrations of the book; but they are more perfect, and bring the pupil a step nearer to the objects themselves.

Besides this special assistance in object-study, the charts will be of great value, later on in the study, by bringing into a narrow compass a complete view of the structures and relations of the leading types of the vegetable kingdom. In fact, they are designed to present, fully and clearly, those groupings of characters upon which orders depend in classification; while in several cases of large and diversified orders the characters of leading genera are also given by typical specimens. The charts will thus be found equally valuable to the beginner, the intermediate pupil, and the advanced student. A Key accompanies them, and they can be used with any botanical text-books, and during the season of plants they should be upon the walls of every school-room where botany is studied.

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THE

FIRST BOOK OF BOTANY.

CHAPTER I.

THE LEAF.

EXERCISE I.

The Parts of a Leaf.

The first question to be asked about a leaf is, What are its parts? You are to study living leaves. Begin by finding and naming their parts. But, first of all, you must get leaves to study.

If you look along the fences, in the yards, gardens, and orchards, in the fields and woods, you will find leaves of many sorts on trees, bushes, and herbs. Break them off carefully, so as to miss none of their parts. It is better (when you are permitted) to get small branches from trees and bushes, and you may often find it best to get the whole of low plants. In this way you will be sure to have the leaves with all the parts belonging to them.

Fig. 1 shows you the parts of a complete leaf, and the name of each part is printed near it.

Blade.—The flattened green part of the leaf.

Pet'iole.—The leaf-stalk.

Stip'ules.—Small bodies at the base of the petiole, that look more or less like leaves.

Look over the leaves you have gathered, and find the blade in each of your specimens; find the petiole, and look for the stipules. Leaves having all the parts

Fig. 1.

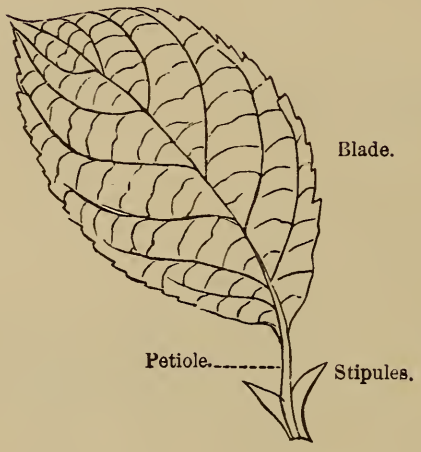


Fig. 2.

seen in Fig. 1 are said to be *complete*. When you find a leaf without a leaf-stalk, but with the blade sitting upon the branch, it is called a *sessile* leaf. (Sessile means sitting.)

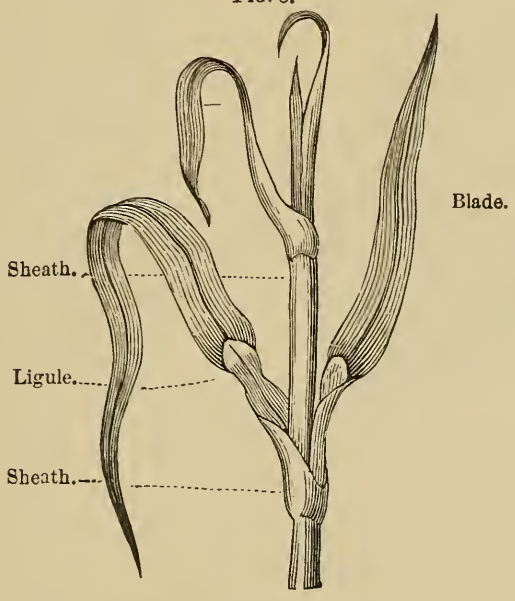
Do not expect to find the parts of leaves shaped just like the figures in the book. Stipules are often very small—mere thread-like bodies, that you may easily overlook. And they are so often absent that perhaps you have not a single *complete* leaf among your specimens. You can easily tell which is blade and which is leaf-stalk in your leaves, and you will know the stipules when you see them.

Point out and give the name of each of the parts

of each kind of leaf you have found. Place the *complete* leaves by themselves. Put the *sessile* leaves together.

The parts of grass-leaves are shown in Fig. 3. You see the BLADE, the flattened upper part of the leaf; and the SHEATH, a leaf-stalk surrounding the

FIG. 3.



stem; then on each leaf there is a LIG'ULE—it is the scale-like stipule on the inside of the leaf between the sheath and the blade.

There are many kinds of plants with leaves made up of parts similar to these of the grass-leaf. Compare grass-leaves with Fig. 3.

EXERCISE II.

Venation.

You already know by name, and can point out, the parts of a leaf. By use you will soon easily remember these names. You have learned the names of hundreds and hundreds of things, by hearing others use them, and by using them yourself. Knowing the name of a thing is not knowing much about it, to be sure; but we must know its name if we are going to talk and write about it. There are a great many different parts in plants, and a great many new words will be needed in their study; but when you are looking at them, and talking and writing about them, you will learn their names without effort.

There is a great deal to be seen in leaf-blades. Hold up a leaf between your eye and the light; you see it covered over with fine lines, and it has also a few coarser lines running through it. Break one of the coarser ones and examine it. Is it woody? Is it hollow? These lines are called *veins*, and all of them taken together are spoken of as the VENATION of the leaf. You see that the spaces between these lines are all filled in with green matter. In some strong-veined leaves this matter can all be dissolved, leaving the veins just as they are now, but naked.

Find where the largest veins begin and end. Where do the finer lines begin and end? Are there more than two sizes of veins?

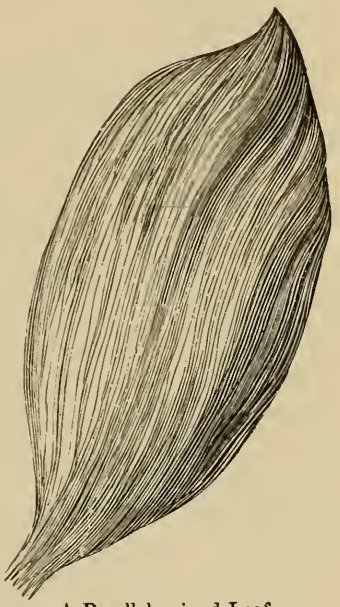
You will need names for these different-sized veins. The largest are called RIBS, the branches from the ribs are called VEINS, and the smallest are called VEINLETS. (See Figs. 6 and 7.) Put by themselves

all the leaves you have in which the veinlets form an irregular net-work, as in Fig. 4. These are known as *net-veined* leaves.

Fig. 4.

A Net-veined Leaf.

Fig. 5.



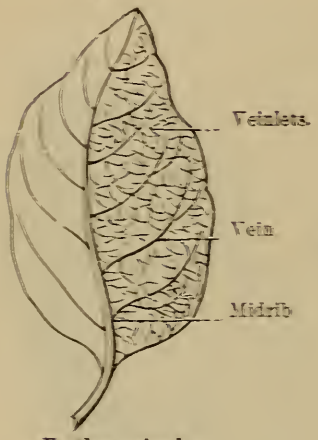
A Parallel-veined Leaf.

Leaves in which no veinlets are seen, and leaves in which the net-work of veinlets is regular, are called parallel-veined, and sometimes fork-veined. Fig. 5 represents a parallel-veined leaf.

Look at each of your *net-veined* leaves, and count its ribs. If it have only one rib, reaching from the leaf-stalk across the blade to its very edge, and giving off veins right and left, as the plume spreads away from the shaft of a feather, it is called a *feather-veined* leaf, and its one rib is named the midrib. If it have several ribs spreading away from the leaf-stalk, as shown in Fig. 7, it is called a palmate-veined leaf. Does Fig. 2 remind you at all of a feather or

quill? Do Figs. 7 and 8 look to youlike your own open hand, with the fingers spreading out from the palm?

Fig. 6.



Feather-veined.

Fig. 7.

Palmate-veined.

Separate your *feather-veined* from your *palmate-veined* leaves.

Fig. 8.

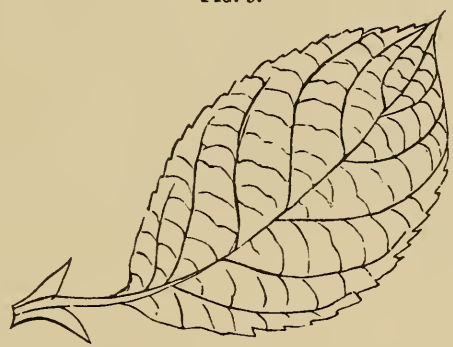
You may not always find it easy to tell whether a leaf is *feather* veined or *palmate* veined. Large veins that start near the leaf-stalk sometimes look very much like ribs. You may make mistakes here at first; but remember that finding out mistakes is a good way to learn.

Did you ever see the frame of a house before it was covered with boards? Did you ever see the bony frame of an animal with all its flesh gone? All the veins of a leaf, taken together, are often spoken of as its frame.

Can you now point out the parts of any leaf you find? Can you tell whether it is net- or parallel-veined? Do you know feather-veined from palmate-veined leaves?

In place of reciting to your teacher a lesson learned from a book, you may find the answers to two questions on each of the leaves you have gathered, and give them in writing as you see done in the following schedule. The first question is, What parts has it? The second is, What is its venation?

Fig. 9.



Schedule First, describing Fig. 9.

Parts?	*Blade, Petiole, Stipules.*
Venation?	*Net-veined.*

This has been done for Fig. 9 to show you how to proceed. Have by you a good many pieces of paper

with these two questions either printed or written upon them, as seen in schedule first. Answer these questions about any leaf, as you see they have been answered about Fig. 9. Pin each bit of paper to the leaf it describes, and give all to your teacher. This will be at once an exercise in botany, in writing, and in spelling; and it will show your teacher what use you have made of the time taken to study plants.

EXERCISE III.

The Margin of Leaves.

Look at the edges of your leaves. Are they all alike? Are all that grow on the same plant alike?

The edge of a leaf-blade is called its *margin*.

Some of the most common forms of margins are here given. Compare your leaves with these figures to find which they are most like. The name of the form is given below the figure, and you are also told how you may name those margins that are not like the diagrams.

Fig. 10.

Entire.

Fig. 11.

Serrate.

Fig. 12.

Crenate.

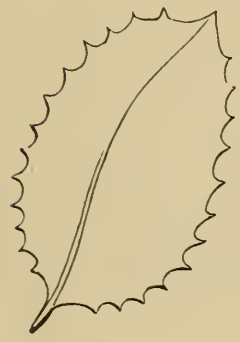
An Entire margin is even and smooth, like Fig. 10.

A Ser'rate margin has sharp teeth pointing forward like a saw (see Fig. 11).

A Cre'nate margin has broad, rounded notches, like Fig. 12.

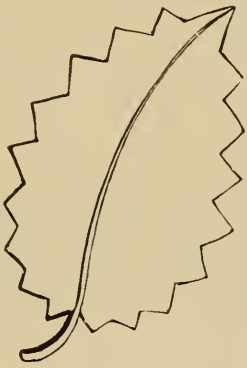
A Den'tate margin has sharp teeth pointing outward. Figs. 13 and 14 are different forms of Dentate margin.

Fig. 13.



Dentate.

Fig. 14.



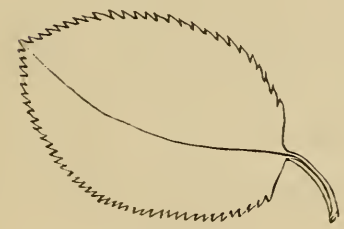
Dentate.

Fig. 15.

Repand.

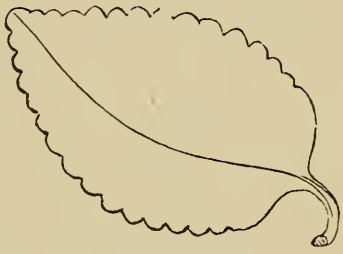
In Repand' (Wavy) margins the edge curves outward and inward, as in Fig. 15.

Fig. 16.



Finely Serrate.

Fig. 17.



Finely Crenate.

Each of these different kinds of margin varies in many ways.

Figs. 16 and 17 show the serrate and crenate mar-

gins, with their notches very small. They are hence described as finely serrate and finely crenate. On the other hand, if the toothing is very large, as in Fig. 18, the margin is coarsely serrate.

When coarsely-notched leaves have finer notches upon their margin, as in Fig. 19, the leaves are said

Fig. 18.

Coarsely Serrate.

Fig. 19.

Doubly Serrate.

to be doubly serrate, dentate, etc. When the notches are of all sizes, and without any order, as in Fig. 20, they are said to be unevenly serrate, or crenate, or dentate. You will often find two or more kinds of toothing upon the same leaf. In such cases, to describe the margin, you have only to put together these names of the different kinds of notches. For instance, if part of the notches are serrate and part dentate, this forms a serrate-dentate margin. If some of the notches are crenate and some serrate, it will be crenate-serrate, and so on.

Such deep notches as are seen in Fig. 21 form lobes, and the margins of these lobes vary like other leaf-margins.

The questions in schedule second are asked con-

cerning Fig. 3, the grass-leaf. Compare the answers with the picture. Add this question to the others of

Fig. 20.

Unevenly Serrate.

Fig. 21.

A Lobed Leaf.

your schedules, and look closely for all these different forms of margin. In answering it you will soon get familiar with the words needed to describe them.

Schedule Second, describing Fig. 3.

Parts?	*Blade, Sheath, Ligule.*
Venation?	*Parallel-veined.*
Margin?	*Entire.*

EXERCISE IV.

The Base and Apex of the Leaf-Blade.

It is a good thing for scholars that leaves quickly wither, and must be gathered afresh for each day's study. It will be strange and very stupid if, in getting the same ones you studied the day before, you do not each day find others that are new to you. You should always try to do this.

When you were studying the venation of your leaf-blades and their margins, perhaps you did not notice that they also differed very much in shape. We are now to begin the study of the forms of leaves, and the first step will be to notice the two ends of the leaf-blade. The lower end, next the stalk, is called the BASE of the blade, and the other end is called the APEX. Fig. 22 represents two leaves placed one upon the other, that are alike in shape of apices but unlike at the base. The names given to the shapes of the bases of leaf-blades are:

FIG. 22.

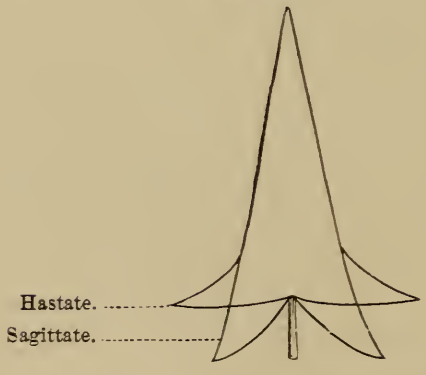


FIG. 23.

HAS'TATE (HALBERD-SHAPED).—When there are spreading lobes at the base, as in the diagram, Fig. 22.

SAG'ITTATE (ARROW-SHAPED).—When these lobes are sharp, and point downward. Fig. 22. When these basal lobes are small and rounded, they are said to be AURIC'ULATE (ear-shaped), Fig. 23.

REN'IFORM (KIDNEY-SHAPED). — When they are broader than long, as seen in the diagram, Fig. 24, where the shapes of five different leaf-blades are shown.

CORDATE (HEART-SHAPED), Fig. 24.—When the whole blade is shaped like a heart, it is said to be *cordate*. But the word may be used in describing the base alone.

FIG. 24.

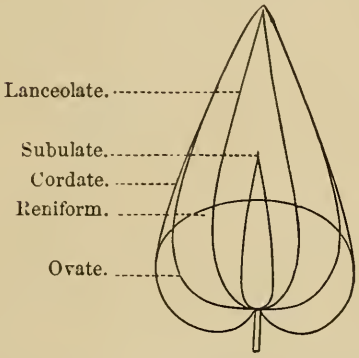


FIG. 25.

OBLIQUE'.—When one side of the base is longer and lower than the other, Fig. 25.

FIG. 26.

FIG. 27.

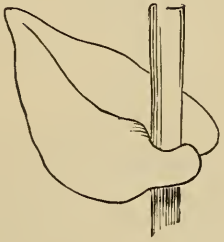


FIG. 28.

TAPERING.—When the blade tapers off at the base. Fig. 26 shows a base that is very tapering.

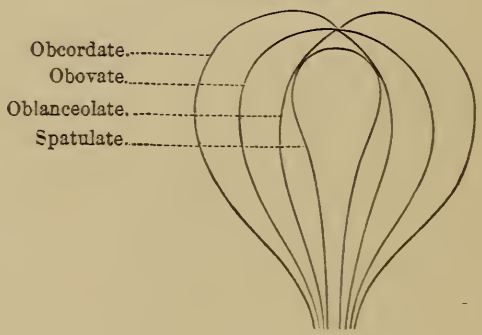
Clasping.—Where the base folds around the stem of the plant, Fig. 27.

Connate'.—Where the bases of two leaves grow together around the plant-stem, as in Fig. 28.

Decur'rent.—Where the lower part of the mid-rib grows to the plant-stem, as in Fig. 29.

Fig. 29.

Fig. 30.



The apex of a leaf is said to be *acute'* when it ends in a point; but if the point is very sharp and tapering, it is *acu'minate*. The cordate leaf-form shown in Fig. 24 has an apex that may be called *acute*. The lanceolate leaf-form has an acuminate apex.

When very blunt, the apex is called *obtuse*. When there is no proper apex, and the end of the blade looks as if it had been cut off, it is said to be *trun'cate*.

It is *emar'ginate* when it has a small, sharp, inward notch at the apex, and *retuse'* when it is rounded inward. But when the apex is rounded inward so as to look like a cordate *base*, it is an *obcor'date* apex. (See Fig. 30.)

When the blade ends suddenly with a short, slen-

der point, it is *cus'pidate;* but if the point is sharp and stiff, it is *mu'cronate.*

The words acute, acuminate, and obtuse, may be used to describe *bases* as well as *apices*, and, when we wish to say that a shape is less acute or less acuminate than those shown in Fig. 24, we may say it is sub-acute or sub-acuminate.

Schedule third again describes Fig. 1. Observe how the three new questions about leaves are here answered.

SCHEDULE THIRD, DESCRIBING FIG. 1.

Parts?	*Blade, Petiole, Stipules.*
Venation?	*Net-veined, Feather-veined.*
Margin?	*Serrate.*
Base?	*Obtuse.*
Apex?	*Sub-acute.*

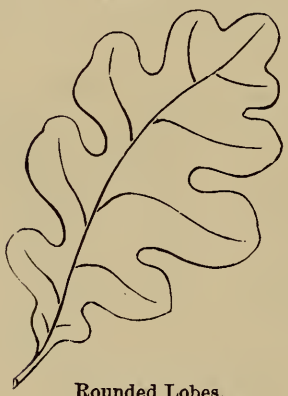
EXERCISE V.

The Forms of Lobes.

BEFORE studying the forms of whole blades, it will be well to look with more care at lobed leaves. Gather as many as you can find; for, the more specimens you study at each exercise, the more you will learn.

The lobe at the apex of a leaf, which is called the *terminal* lobe, and those at the base, called the *basal* lobes, have to be first noticed. Are they alike in the same leaf? Are they like the other lobes of the leaf?

Fig. 31.



Rounded Lobes.

Fig. 32.

Acute Lobes.

Observe whether the lobes are round like Fig. 31, or sharp like Fig. 32.

Add the question Lobes? to your schedule, and when you answer it in regard to a leaf, say how many lobes it has, and whether they are round or sharp. If the terminal or the basal lobes are larger, smaller, or different in shape from the others, you can put down the fact in answer to the questions Base? and Apex? When feather-veined leaves are lobed, they are said to be pinnately lobed (from *pinna*, a feather), and palmate-veined leaves, Fig. 32, are said to be palmately lobed.

Look your specimens over once more, to see whether the spaces between the lobes are alike in all of them. The space between two lobes is called a si′nus. Look at the names given to the different sinuses in the following figures.

Fig. 33.

Open Sinus.

Fig. 34.

Shut Sinus.

Fig. 35.

Lobes Spreading.
Sharp Sinus.

When feather-veined leaves have deep lobes, they are said to be pinnatifid.

Fig. 36.

Broad, round, shallow Sinus.

Fig. 37.

Round, deep Sinus.

Fig. 33, with its open sinus, is further described as regularly pinnatifid. If the pupil choose, Fig. 34 might be said to have its lobes overlapping, and Fig.

35 its lobes spreading, in place of referring to the sinus.

Fig. 38.

Sharp and deep Sinus.

EXERCISE VI.

The Shapes of Leaves.

You have seen that leaves take on many different shapes. All the leading forms which they assume are shown in this exercise. Each figure has a name of its own; but you need not fear the task of learning so many new words. Give yourself no trouble about it. When you find a leaf that is like any figure here given, use the name given to the figure in describing the leaf, and, by doing this over and over, you will find that the word will seem to become part of the shape. When you see the shape, the word will come at once into your mind. Never try to learn botanical names in any other way. Be sure that, if you really study plants as they abound everywhere, the language needed to describe them will be learned without any sense of effort. If you collect

and describe as many leaves as you should, you will have abundant use for every one of the terms here given.

For the present, put aside your lobed leaves.

The first eighteen diagrams are divided into three groups :

(*a.*) Figures of leaves that are broadest in the middle.

(*b.*) Figures of leaves that are broadest at the base.

(*c.*) Figures of leaves broadest at the apex.

You will know at once which of these groups to compare a leaf with.

Do not expect to find your specimens exactly like the figures. Give them the names of the forms they most resemble.

When a leaf seems to be about equally like any two figures, join together the names of these two forms in describing it, as seen in Fig. 42.

(*a.*) LEAVES THAT ARE BROADEST IN THE MIDDLE.

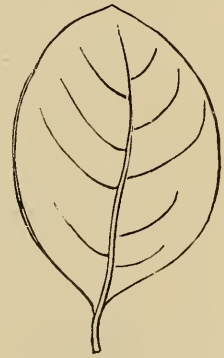
Fig. 39.

Orbic'ular.

Fig. 40.

Rotun'date.

Fig. 41.



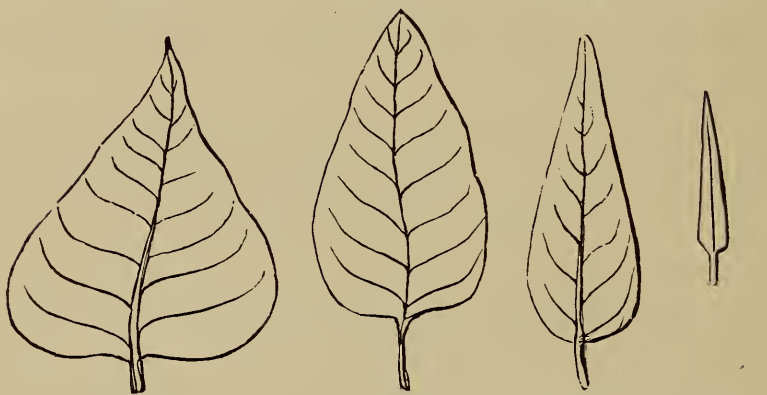
Broadly elliptical.

FIG. 42. FIG. 43. FIG. 44. FIG. 45.

Oblong elliptical. Oblong. Linear. Acic'ular.

(*b.*) LEAVES THAT ARE BROADEST AT THE BASE.

FIG. 46. FIG. 47. FIG. 48. FIG. 49



Del'toid. Ovate. Lanceolate. Awl-shaped

FIG. 50. FIG. 51. FIG. 52.

Cordiform. Hastate. Sagittate.

(*c.*) LEAVES THAT ARE BROADEST AT THE APEX.

FIG. 53. FIG. 54. FIG. 55. FIG. 56.

Obcordiform. Obo'vate. Oblan'ceolate. Spat'ulate.

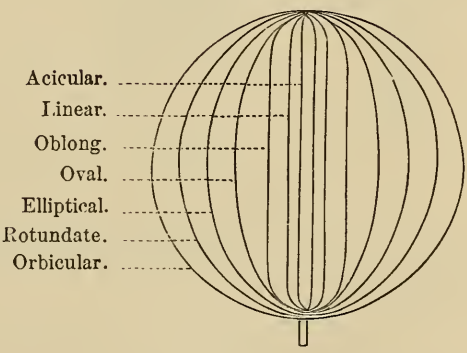
Fig. 57 represents a *peltate* leaf. It is an unusual and striking leaf-form.

PELTATE leaves are round, and have the petiole attached near the middle of the under surface of the blade, Fig. 57.

FIG. 57.

Peltate.

FIG. 58.



The forms shown in Fig. 58 are a repetition of those shown in group *a*, and will help the scholar in

forming a correct idea of the shape that goes with any of these names.

In studying lobed leaves you will find a good many very singular forms, concerning which it would be hard to answer the questions in the schedule. Some of these forms are here pictured. When you find in your collection lobed leaves that are very peculiar, compare them with these pictures and definitions.

A Run'cinate leaf is a lobed feather-veined leaf, in which the lobes point backward toward the base, Fig. 59.

Fig. 59.

Runcinate.

Fig. 60.

Bipinnatifid.

Fig. 61.

Pedate.

Bipinnat'ifid leaves are formed when a deeply-lobed feather-veined leaf has its lobes again lobed, as in Fig. 60.

A Ped'ate leaf is a lobed palmate-veined leaf, in which the lobes at the base are lobed again, and give the leaf a look like the foot of a bird, Fig. 63.

Laciniate.—Leaves are so named when they look

as if they had been gashed with scissors. Fig. 62 is an example of such a leaf.

A LYRATE leaf is a lobed feather-veined leaf, with

FIG. 62.

Laciniate.

FIG. 63.

Lyrate.

the terminal lobe much larger than the others, Fig. 63.

Fig. 62 is described in schedule fourth, where, in saying the shape is Laciniate, the questions Base? Apex? and Lobes? are all answered.

SCHEDULE FOURTH, DESCRIBING FIG. 62.

Parts?	*Petiole, Blade.*
Venation?	*Palmate-veined.*
Margin?	
Shape?	*Laciniate.*

EXERCISE VII.

The Petiole, Colors, Surface.

If you have gathered and studied all the leaves you could find, as directed in former exercises, when now you look at leaves you notice what parts make them up, their style of venation, their margins, their shapes at their bases and apices; if they are lobed leaves, you inspect and count the lobes, and you try to say in one word, if possible, what is their general shape.

Put three more questions to this list, and when all are answered you have given a botanical description of a simple leaf. The first of these new questions is, Petiole? Tell whether the petiole is roundish, angular, furrowed, long or short, straight or crooked, stiff or flexible.

The next question is, Color? Have you not seen that leaves vary in color from dark to light green; that they are sometimes spotted, or striped with brown, red, and other colors; that the under side often has one color, and the upper another? This question will be easily answered.

Then you must observe the qualities of the surface of a leaf. If it is not hairy, botanists call it *glabrous*. They have a word also for densely woolly surfaces—*tomentose*. Sometimes the surface is very shiny. In answering this question, put down whatever appears to be the character of the surface you are describing.

The surfaces of plants are said to be Silky when the hairs are long, very fine, and pressed down closely, so as to present a silky appearance.

The schedule is now made up of the following ten questions:

Schedule Fifth.

Parts?	
Venation?	
Margin?	
Base?	
Apex?	
Lobes?	
Shape?	
Petiole?	
Color?	
Surface?	

While in a book we must give a fixed order of exercises, it is well if teachers use their own judgment in following this order. Often much will be gained by changing it. There are minds that demand variety, or their interest flags; and the minds of children, especially, are liable to grow weary of continued attention to one class of objects. Before proceeding with the exercises upon compound leaves, it may, therefore, be advisable to turn to the chapter upon the Inflorescence, or that upon the Flower, and occupy a little time with the opening exercise in which the names of parts are brought before the mind. The identification and naming of the parts of flowers will be easier to most children than finding the differences between simple and compound leaves; while dealing with another and more showy portion of the plant will stimulate the attention.

The use of schedule fifth should, however, still be kept up, and, after a little while, the pupil will come back to the study of compound leaves with a fresh relish for the subject.

EXERCISE VIII.

How to tell Compound Leaves.

THE next time you search for leaves, remember that some leaves have more than one blade, as shown in Fig. 65. When you see a leaf with several blades

FIG. 64.

FIG. 65.

growing from the petiole and its continuation, call it a *compound* leaf, and call each of these blades a *leaflet.* It is sometimes difficult to tell a simple from a compound leaf, and this is the reason that I did not call attention to them before. You have to learn: first, the differences between simple leaves without lobes and compound leaves; and second, the differences between lobed leaves and compound leaves.

A *simple* leaf has only one blade, as in Fig. 64. Any leaf with more than one blade is *compound.* If

you have been describing leaflets as if they were simple leaves, you must now be careful not to make this mistake.

Your chief difficulty will be to know leaflets from the lobes of deeply-lobed leaves. It is said that leaflets are *jointed* to the stalk, and you may know a joint by the smooth end of the broken-off petiole; but this is not always true. Leaflets may be found in all stages of union with the stem, and there is no way of being sure which is which but by patiently studying the leaves themselves. It requires a good deal of judgment, but there is no harm in making the attempt, even if it is likely to be often a failure.

Another way of settling the question is to see if the green matter reaches all around the framework, and is continued down the common stalk (Fig. 66).

Fig. 66.

Lobes.

Fig. 67.

Leaflets.

This never happens in the case of leaflets. The way leaflets differ from deep lobes is shown in Fig. 67.

If you make mistakes in this matter, never mind. Each mistake will help you on, if you keep trying to learn.

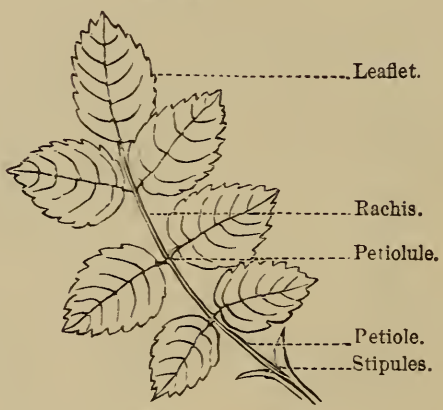
EXERCISE IX.

Parts of Compound Leaves.

LEAVES, in growing, are sometimes changed from simple to slightly lobed, from slightly to deeply lobed, and from lobed to compound. When feather-veined leaves, with their stout middle rib, are thus changed, they become pinnately lobed, or pinnately compound as in Fig. 68.

Leaves with several ribs, palmate-veined leaves,

FIG. 68.



become palmately lobed or palmately compound, as shown in Fig. 69. They are usually called digitate leaves, from the resemblance of the leaflets to fingers.

LEAFLET.—One of the blades of a compound leaf.

PET'IOLULE.—The stem of a leaflet.

STI'PELS.—The stipules of leaflets.

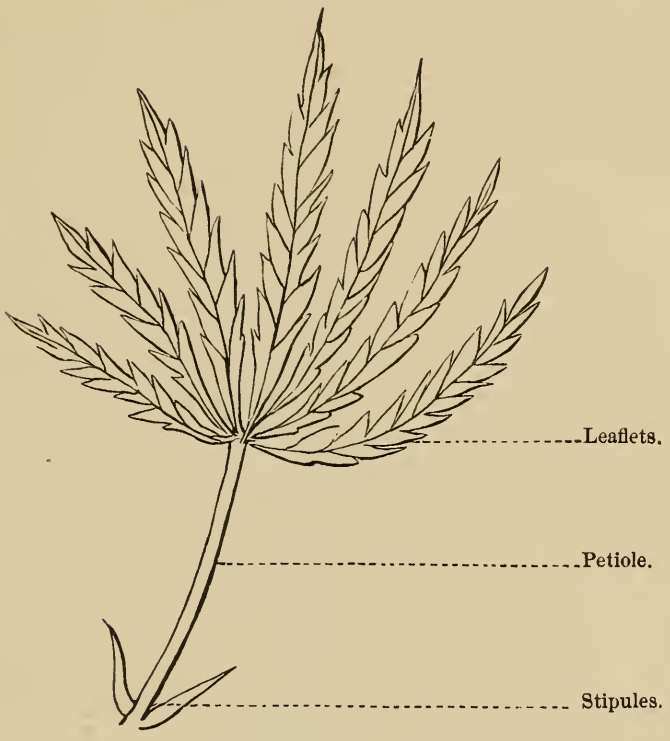
RA'CHIS.—The continuation of the petiole to which leaflets are attached.

Gather a great many compound leaves and look for their different parts.

The parts of different kinds of compound leaves

are shown in Figs. 68, 69, and 70, along with the meaning of all the names you do not already know.

Fig. 69.



By comparing your specimens with these figures you will be able to fill out a compound-leaf schedule, having the two questions shown in schedule sixth. Do not pass on to the next exercise till you have found the parts of dozens of different kinds of compound leaves.

Schedule Sixth, describing Fig. 68.

Parts.	*Rachis, Petiole, Stipules, Leaflets.*
No. of Leaflets.	*7. Feather-veined, Serrate, Ovate.*

Observe the venation, margin, shape, etc., of leaflets as you have done in studying simple leaves. You

Fig. 70.

see, in schedule sixth, that the leaflets are described as feather-veined, serrate, ovate.

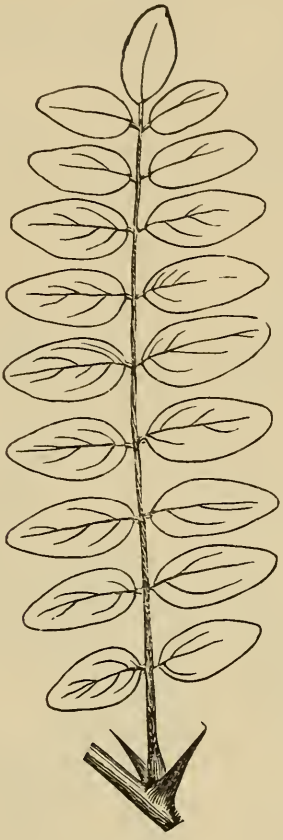
EXERCISE X.

Varieties of Pin'nate and Dig'itate Leaves.

Compound leaves, then, having parts similar to those shown in Figs. 65, 68, 71, are called pinnate leaves; and when the parts are joined as in Figs. 78 and 79, they are called digitate leaves. But there are a great many kinds of both pinnate and digitate

leaves. Gather some compound leaves and separate the pinnate from the digitate ones. Observe the dif-

Fig. 71.

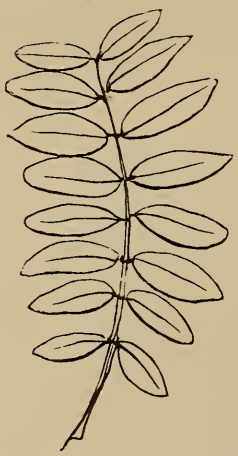


ferent forms of pinnate leaves. Leaves are said to be UNEQUALLY PINNATE when they end with an odd or single leaflet, Fig. 71.

A leaf is said to be ABRUPTLY PINNATE when it ends with a pair of leaflets, Fig. 72.

INTERRUPTEDLY PINNATE.—When the leaflets are alternately large and small, Fig. 73.

Fig. 72.

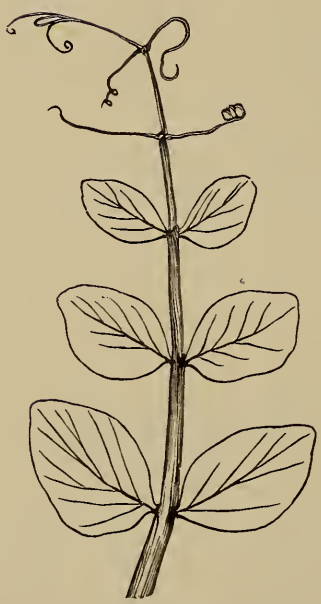


Abruptly Pinnate.

Fig. 73.

Interruptedly Pinnate.

Fig. 74.



Cirrous.

Fig. 75.

Twice Pinnate.

Fig. 76.

Thrice Pinnate.

Fig. 77.

Three-fingered.

Fig. 78.

Five-fingered.

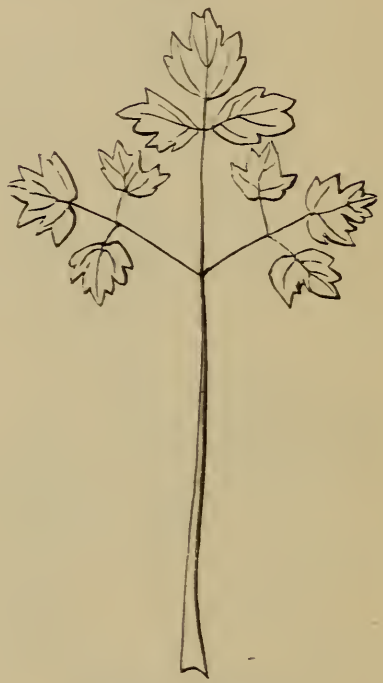
Cirrous. — When the rachis ends in a tendril, Fig. 74.

Twice Pinnate.—When the petiolule is continued as a rachis which bears the leaflets, Fig. 75.

Fig. 79.

Seven-fingered.

Fig. 80.



Twice Three-fingered.

Tri-Pinnate.—When the leaflets are borne upon a third rachis, branching off from the second, Fig. 76.

Of digitate leaves the varieties are the trifoliate or three-fingered (Fig. 77); the five-fingered (Fig. 78); the seven-fingered (Fig. 79); and the twice three-fingered (Fig. 80).

Five-fingered.—A digitate leaf with five fingers or leaflets.

SCHEDULE SEVENTH, DESCRIBING FIG. 75.

Parts?	*Petiole, Rachis, Leaflets.*
No. Leaflets?	*10. Oval, Entire.*
Kind?	*Pinnate.*
Variety?	*Cirrous.*

EXERCISE XI.

Stipules and Leaf-Schedules.

STIPULES are said to be

FREE.—When not united to any other part, and

ADNATE. — When they grow to the petioles, as in Fig. 1.

OCHREATE. — When they form a sheath round the stem, Fig. 81.

FIG. 81.

MEMBRANOUS. — When like the dried skin of animals, and

PRICKLY.—When like those shown in Fig. 71.

All leaves, whether simple or compound, are said to be STIPULATE if they have stipules, and EX-STIPULATE if without stipules.

Any leaf with a petiole may be described as a PETIOLATE leaf, and any leaf without a petiole as a SESSILE leaf.

EXERCISE XII.

How to describe Leaves without Schedules.

Pupils who have been diligent in the use of the preceding schedules ought now to be able to describe leaves without their aid. This exercise gives two such descriptions. They follow the same order as that given in the schedules. The first is a description of Fig. 1.

The *blade* is simple, petiolate, stipulate, net-veined, feather-veined, serrate, abruptly acuminate, oval; *petiole* short; *stipules* adnate.

The second describes Fig. 65, which represents a

Compound, petiolate, stipulate, unequally pinnate leaf. *Leaflets* 5, petiolate, feather-veined, serrate, ovate; *stipules* adnate.

With the next chapter you begin the study of stems. But you must not stop observing leaves if you are to remember what you have learned. In most cases it takes a good deal of *time* and many repeated observations to fix impressions in the mind so that they will not be forgotten. It often happens that we get familiar with the appearance of objects in a short time when we observe them intensely, but this familiarity is not lasting unless the attention is prolonged, or the impressions are revived at intervals. It will be best, therefore, to continue to describe leaves in the above form upon the stem-schedules that follow.

In punctuating these descriptions—1. Separate adjectives relating to the same noun by commas; 2. Parts of the same organ by semicolons; 3. Distinct organs by a period.

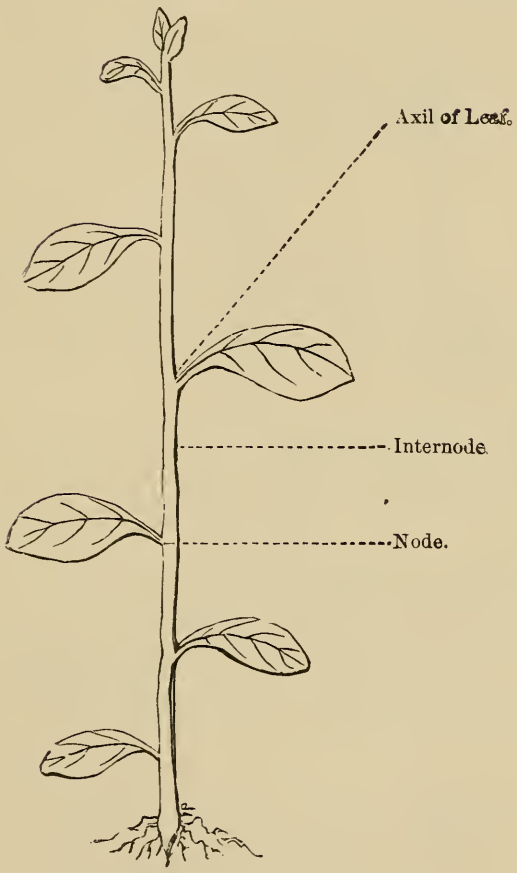
CHAPTER II.

THE STEM.

EXERCISE XIII.

The Parts of Stems.

FIG. 82.



Nodes and Internodes.

If you compare the stems of plants with Fig. 82, you will find them made up of the parts here pointed out. At certain places, called nodes, along the stem,

Fig. 83.

a leaf or leaves will be seen, with bare spaces between. In Fig. 82 the stem is made up of these spaces, each with a leaf at its top. Find the *nodes*

upon the specimens you have collected for study. Find the leaf-axil in your living plants.

The Node, or joint of a stem, is the point from which leaves are given off.

The Internode is the portion of stem between two nodes.

The Leaf-Axil is the point at the upper side of the leaf where it joins the stem.

Observe whether the nodes of plants are swollen and watery (tumid); whether they are hairy or of a different color from the internodes. Look carefully to see if stems are jointed at the nodes.

Observe the parts pointed out in Fig. 83, and look for like parts in the plants before you.

Terminal Bud.—The bud at the end of the stem.

Axillary Bud.—The bud in the axil of a leaf.

Branch.—A stem which grows from an axillary bud. It is sometimes called a secondary stem, and the stem from which it starts is said to be the primary stem.

Is the branch made up of the same parts as the main stem? Do you find branches growing from axillary buds in your specimens?

Do not pass on to the next exercise till you have examined a great many stems, found all the parts shown in Figs. 82 and 83, and become so familiar with their names that when asked to point out a leaf-axil or a node or internode, you can do it promptly and with confidence.

EXERCISE XIV.

Vernation.

Vernation is the way in which leaves are folded, rolled, or arranged in the bud.

Fresh buds are constantly appearing throughout the growing season at the tips of stems and in the axils of leaves. Observe the way in which the parts of these buds are packed together. Observe them when they are just opening. If you are watchful, you will be sure to find them at a moment when the growing leaves have not yet lost the shapes they had while packed in the bud.

The chief ways in which leaves are rolled and folded in buds are shown in the following illustrations.

Fig. 84.

Reclinate.

Fig. 85.

Circinnate.

FIG. 86.

Conduplicate.

FIG. 87.

Plicate.

FIG. 88.

Convolute.

Rec'linate, or Inflexed'.—Folded from apex to base, Fig. 84.

Cir'cinate.—Rolled from apex to base, Fig. 85.

Fig. 89.

Condu'plicate.—Folded along the midrib so that the two halves are applied to each other, Fig. 86.

Pli'cate.—Folded like a fan, Figs. 87 and 88.

Con'volute.—With the leaf rolled spirally so that one edge is in the center of the coil and one outside, Fig. 89.

In'volute.—With both edges rolled inward toward the midrib, Fig. 90.

Rev'olute.—With both edges rolled outward toward the midrib, Fig. 91.

Fig. 90.

Involute.

Fig. 91.

Revolute.

When leaves are neither folded nor rolled in the bud, they are said to be *flat.*

ARRANGEMENT OF LEAVES IN THE BUD.

By the arrangement of the leaves in a bud is meant the ways in which they are placed in relation to each other. For instance, Fig. 92 shows what is called the *equitant* arrangement.

FIG. 92.

Equitant.

EQ'UITANT.—When opposite conduplicate leaves overlap each other at the base.

Leaves are always arranged in one or other of the two ways called valvate and imbricate.

The VAI'VATE arrangement is seen when the edges of corresponding leaves barely touch each other.

The IM'BRICATE arrangement is seen when the edges of the leaves overlap each other. Fig. 92 shows an imbricate arrangement.

The directions for observing the folding and rolling of leaves apply also to the study of their arrangement. But there are several different ways in which imbricate leaves are placed, and it is sometimes quite difficult to make them out. The best way to study the arrangement of leaves in the bud is to cut off the top of the bud with a sharp knife, and look down on the cut edges, which will show not only whether the leaves are imbricate or valvate, but also, if they are imbricate, the particular mode of overlapping. In most cases, however, a magnifying-glass is needed to show these details.

EXERCISE XV.

Winter Buds.

THE time to study winter buds is in early spring. At this season gather buds from all the trees and shrubs within your reach.

Compare them with Figs. 93 and 94.

Choose a swollen bud, and cut through it, as shown in Fig. 95. Can you find in it the parts there shown?

BUD-SCALES.—The covering of winter buds, Figs. 93, 94.

GROWING-POINT.—The soft extremity of the stem at the center of the bud, and inclosed in the young unexpanded leaves and the bud-scales *a*, Fig. 95.

UNEXPANDED LEAVES are found in buds, as seen in Fig. 95.

Are any of your buds without a protective covering to the growing-point?

Observe in each case whether the scales are mem-

branous, waxy, gummy, lined with down, wool, or dense hairs, or varnished upon the exterior.

Fig. 93.

Fig. 94.

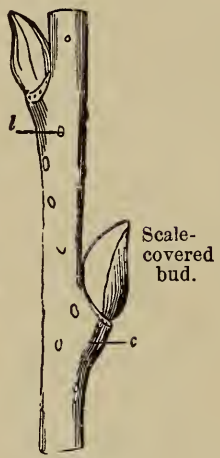
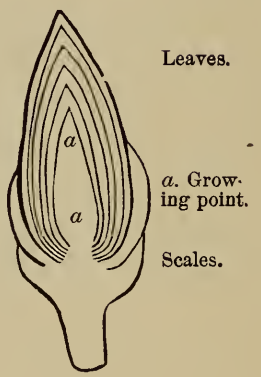


Fig. 95.



What is the use of the gummy matter, varnish, and wax, around the bud?

Of what use are the woolly, downy, and hairy linings of the bud-scales?

What separates the gummed bud-scales when growth begins?

When you are familiar with the winter aspect of the buds upon the trees around, you will be interested in their unfolding. Observe what becomes of the bud-scales on each of the trees you have examined. Scales may be changed into other parts, or they may fall off altogether. Observe these changes. Notice the scars left by their fall.

Pet'iolar scales are formed from the petiole.

Stip'ular scales are formed from the stipules.

Folia'ceous scales are formed from the blade of the leaf.

By frequent observations made during their growth, you will be able to answer the following questions in regard to each sort of bud you have found.

QUESTIONS ON THE BUDS OF A PLANT.

When do the buds begin to swell?

How long are they in unfolding?

Are they naked, scaly, woolly, or gummy?

Can you find the growing-point within them?

Is there any appearance of leaves within them?

What are the size, color, and structure of the bud before swelling commences?

How long is it from the first bursting of the bud till the leaves are full grown?

What changes of color do the leaves undergo during growth?

Are the first-formed leaves as large as those formed later in the season?

What becomes of the bud-scales as the buds unfold?

In studying the leaves of a plant, you will now observe the vernation, and it may be given in your leaf-description.

EXERCISE XVI.

Arrangement of Leaves on the Stem.

Alternate Leaves.—Leaves are alternate on the stem when there is but one at each node, as in Fig. 96.

Opposite Leaves.—When two leaves grow opposite each other, we call it the *opposite* arrangement, Fig. 97.

Whorled Leaves.—When there are more than two leaves at a node, we say the leaves are *whorled*, Fig. 98.

Fig. 96.

Alternate Leaves.

Fig. 97.

Opposite Leaves.

Besides pointing out the parts of a stem, can you now determine the vernation of the buds upon it? Can you describe the leaf-arrangement? You can

Fig. 98.

Whorled Leaves.

easily find plenty of examples of all the kinds of vernation shown in the foregoing exercises, and of the three modes of leaf-arrangement shown in this.

EXERCISE XVII.

Radical Leaves.

In Fig. 101 the leaves seem to grow from the root, and so are called radical leaves. But they really

Fig. 99.

Stem Leaves.

Fig. 100.

grow from very short stems, like the one shown in Fig. 100. Here you see that the nodes are crowded

closely above each other, and no internodes are formed. Examine plants with radical leaves, and find their nodes all packed together close upon the root.

Fig. 101.

Radical Leaves.

When you describe leaves, you should hereafter say that they are radical, when they seem to grow from the root, and when they grow along the stem you should state whether they are alternate, opposite, or whorled. For instance, the leaf-description of Fig. 97 would read thus: Leaves opposite, petiolate, exstipulate, palmate-veined, serrate, base cordate, five-lobed, terminal lobe acuminate, leaf broader than long.

EXERCISE XVIII.

Attitude of Stems.

ERECT stems stand upright, Fig. 102.

DROOPING stems are weak, and bend over, Fig. 103.

FIG. 102.

Erect.

FIG. 103.

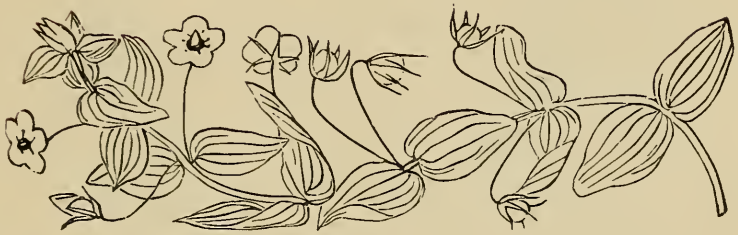
Drooping.

CREEPING stems lie along or below the surface of the ground, and send down roots from their nodes, Fig. 104.

Fig. 104.

Creeping.

Fig. 105.



Trailing.

Fig. 106.

Ascending.

Trailing stems are weak, and lie loosely along the ground, Fig. 105.

Ascending stems stand slanting, Fig. 106.

Fig. 107.

Climbing.

Fig. 108.

Twining.

Climbing stems are weak, and cling by tendrils to the objects about them, Fig. 107.

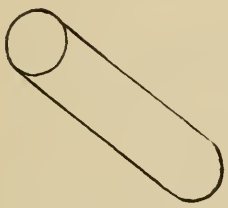
Twining stems are too weak to stand alone, and support themselves by winding around other stems, Fig. 108.

EXERCISE XIX.

Shapes of Stems.

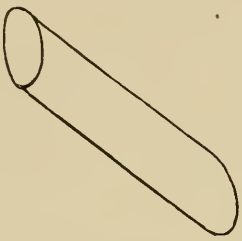
THE following are by no means all the shapes, nor are they the precise shapes, that stems assume, but

FIG. 109.



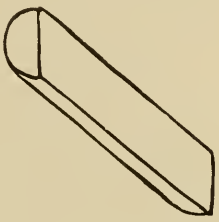
Rounded.

FIG. 110.



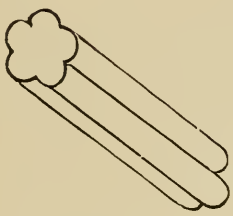
Compressed.

FIG. 111.



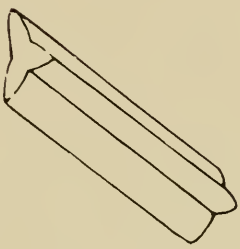
Half-rounded.

FIG. 112.



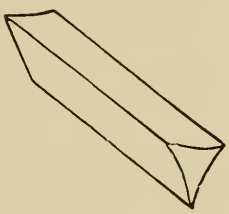
Fluted.

FIG. 113.



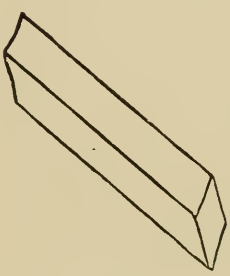
Acute-angled.

FIG. 114.



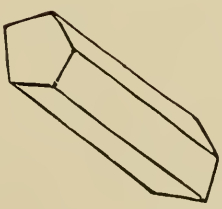
Triangular.

FIG. 115.



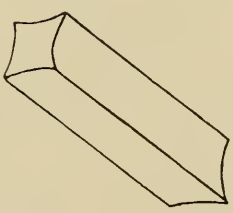
Square.

FIG. 116.



Five-sided.

FIG. 117.



Four-angled.

their forms will most commonly be found to approach very nearly to some of these outlines.

EXERCISE XX.

Color, Surface, Size, Structure.

Color.—Stems may be spotted, striped, green, brown, red, or purple. Surface.—The surface of a stem, like that of leaves, may be smooth, rough, shiny, dull, hairy, or glabrous. Size.—Stems may be high or low, slender or thickened.

Structure.—To find out the structure of a stem, you must break it, and observe first whether it is *hollow* or *solid*. Next see if it is thready: these threads are *woody* fibers, and, when present, they help to make the stem hard and tough. It is then called a Woody stem; but, if it is soft and brittle, it is an Herbaceous stem.

The hairs of plants are Arachnoid, when very long, and loosely entangled, so as to resemble cobweb. Bearded, when the hairs are long, and placed in tufts. Downy, or Pubescent, when the hairs form a short, soft layer, which only partly covers the skin. Hairy, when the hairs are rather longer, and more rigid. Villous, when very long, very soft, erect, and straight. Velvety, short, soft, very dense, but rather rigid, forming a surface like velvet.

There are six questions that you have found it very easy to answer about stems. Here they are, put together in the form of a stem-schedule. If you can remember all these questions, and answer them one after another, as the questions of the leaf-schedule are answered in leaf-descriptions like that of Fig. 97, on page 70, there will be no need of using the schedule. But it is very well to use it for a few days, till the points to be observed are all fixed in the mind.

Schedule Eighth, of the Stem.

Shape?	
Attitude?	
Color?	
Surface?	
Size?	
Structure?	

EXERCISE XXI.

Underground Stems.

In your study of stems you must have seen many like Fig. 100, made up wholly of nodes, so crowded upon each other that the leaves they bear seem to grow out of the ground. You have now to learn that there are various kinds of underground stems, and before you can find them you must know the difference between a stem and a root.

Pull up a buttercup, or any common plant, and rinse away the dirt from the roots. Compare the tip of a rootlet with the tip of a branch. Are they alike? Do you find the roots made up of nodes and internodes? Are there buds on the roots? Pull up

another plant and compare the root and stem in the same way. Do you find the same differences? Compare the root and stem of a great many plants, and see if the differences you first noted are not always found.

You may perhaps find parts of plants under ground that bear buds or are a sort of bud; but they are not common, and they are not roots. By-and-by, when you have studied the mode of growth of plants, you will find further differences between root and stem, but for the present you may know stems from roots by the presence of buds upon them.

Look at a potato that has begun to sprout. Can it be a root? It is a thickened portion of an underground stem, and botanists call it a TUBER. In Fig.

FIG. 118.

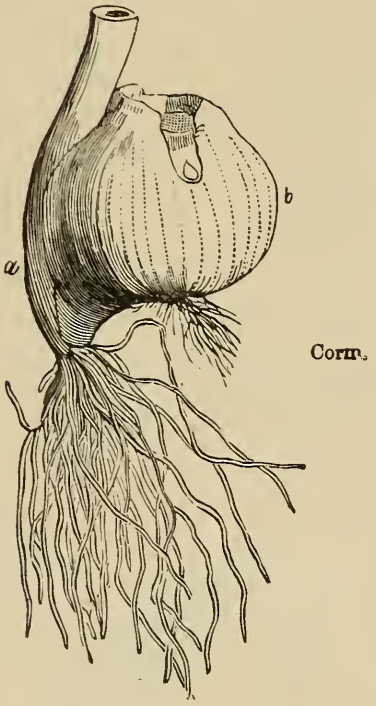
Tuber.

118 you can see the nodes of this underground stem. Observe that roots are given off at these nodes the same as in the creeping stem shown at Fig. 104. Look for examples of roots given off from the nodes of stems that grow only above ground.

Other forms of underground stems are—

The Corm (Fig. 119).—Here the base of the stem

Fig. 119.



is abruptly thickened just below the surface of the ground, so as to resemble a tuber.

The Bulb (Fig. 120).—A mass of thickened, scale-like leaves growing from a flat or conical base. From the under side of this base, roots are given off.

Fig. 121 shows a vertical section of the bulb.

The Rhizoma.—A stem more or less covered by the soil, from the nodes of which buds are given off above and roots below (Fig. 122).

Pull up a growing onion and find its root and stem.

Fig. 120.

Bulb.

Fig. 121.

Section of Bulb.

Find the root and stem of a growing hyacinth; of a lily; of sweet-flag, peppermint, solomon's-seal, artichoke.

Fig. 122.

Rhizoma.

If you can not get at these plants at once, be sure to study their roots and stems when you do find them.

CHAPTER III.

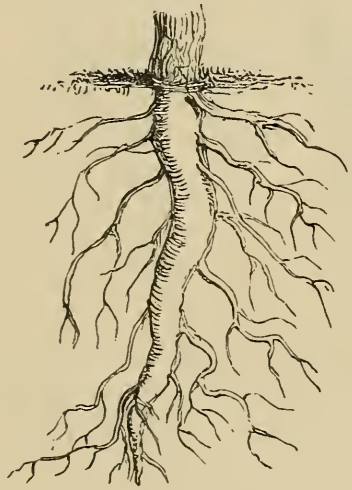
THE ROOT.

EXERCISE XXII.

Tap-Roots and Fibrous Roots.

From underground stems we pass to the study of roots. The different forms they assume are easily remembered, and when you have studied them in connection with the following two exercises of this

Fig. 123.



Tap-root.

Fig. 124.

Fibrous Root.

short chapter, you will be able to give a full and precise description of the root, stem, and leaves of a plant. They are the vegetative organs of plants, and

were so named to distinguish them from flowers, the reproductive organs of plants.

The first question about the roots of a plant is, Are they fibrous (like Fig. 124), or has the plant a tap-root?

A tap-root is a continuation of the stem downward, which may branch, as seen in Fig. 123, or bear fibers, or be nearly smooth, as in Figs. 125, 126, 127.

Fig. 125.

Conical Root.

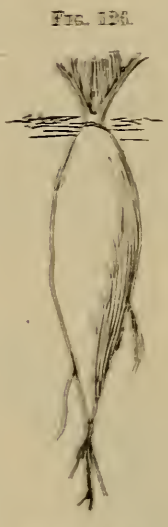


Fig. 126.

Fusiform Root.

Fig. 127.

Napiform Root.

When there is no such downward growth from the stem, but in its place you find a mass of fibers like Fig. 124, you describe the plant as having fibrous roots.

Some of the different shapes of roots have special names, which are commonly used in describing plants. The chief forms of tap-root are—

Con'ical (Fig. 125).—Where the root is seen to be cone-shaped.

Spindle-shaped, or Fu'siform (Fig. 126).—Enlarged in the middle, and tapering toward the ends; and

Turnip-shaped, or Na'piform (Fig. 127).—Plants with such tap-roots as these have very short stems, made up of nodes alone. (See Fig. 100.)

Some of the most common forms of fibrous roots are here shown.

In Monil'iform Roots (Fig. 128) some of the

Fig. 128.

Moniliform Root.

Fig. 129.

Fasciculated Root.

fibers have numerous small swellings, that succeed each other so as to look like a string of beads.

In Fascic'ulated Roots (Fig. 129) the fibers become swollen along their length, and look like a bundle of fusiform roots.

When some of the rootlets of fibrous roots become

fleshy and enlarged, taking the form shown in Fig. 130, they are called Tubercular Roots.

It is easy to see that the moniliform root is only a fibrous root, in which regular portions of the fibers have become swollen. When all these swellings unite in one continuous enlargement, they form a fasciculated root (Fig. 129). When the swellings are shortened and globular (Fig. 130), they form tubercular roots.

With the help of these figures and their explana-

Fig. 130.

Tubercular Root.

tions, you should use your best judgment to decide what is the variety of tap or fibrous roots to which the plant you are studying belongs.

It is also well to note whether the root is small or large compared with the stem and branches; whether it is loosely or firmly planted in the soil: and whether it spreads near the surface or grows downward.

CHAPTER IV.

THE INFLORESCENCE.

INFLORESCENCE.—The way flowers are placed upon plants is called their *inflorescence.*

EXERCISE XXIII.

Solitary and Clustered Inflorescence.

WHEN only one flower grows upon a flower-stem the inflorescence is said to be SOLITARY, Fig. 131.

FIG. 131.

Solitary Inflorescence.

FIG. 132.

Clustered Inflorescence

When several flowers grow from the same flower-stem the inflorescence is CLUSTERED, Fig. 132.

Point out upon the chart all the flowers that are clustered.

Gather all the plants you can find that are in blossom. Separate the clustered from the solitary flowers, and they will be ready for study. You should first learn the names of the parts of a flower-cluster. These are given in the next exercise.

EXERCISE XXIV.

Parts of the Inflorescence.

You will find the parts pointed out for you in the pictures.

PEDUN'CLE.—The stem of a solitary flower, or of a flower-cluster.

RA'CHIS.—The continuation of a peduncle, from which flowers branch off.

BRACTS.—The small leaves of a flower-cluster on the peduncle, or rachis.

INVOLU'CRE.—A whorl of bracts.

PED'ICEL.—One of the flower-stems in a cluster.

BRACT'LETS.—Very small leaves growing upon pedicels.

RECEP'TACLE.—The top of a peduncle, from which several flowers start together.

Can you find upon the chart any flower-clusters with an involucre? Can you find bracts or bractlets in any of the clusters of the chart?

Point out and name all the parts of the flower-clusters you have gathered.

Fig. 133.

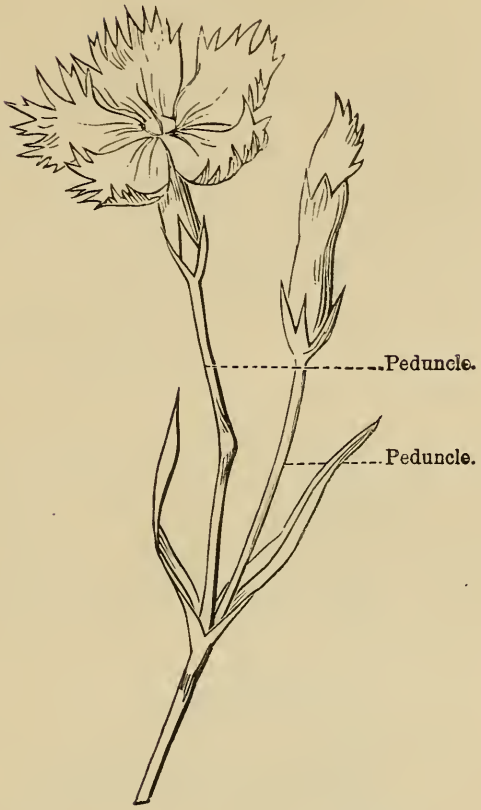


Fig. 134.

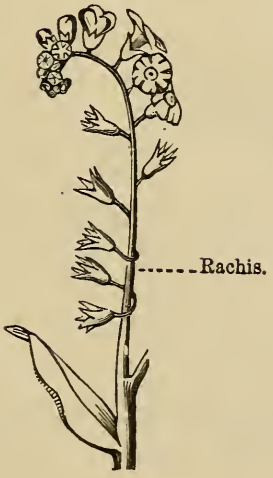
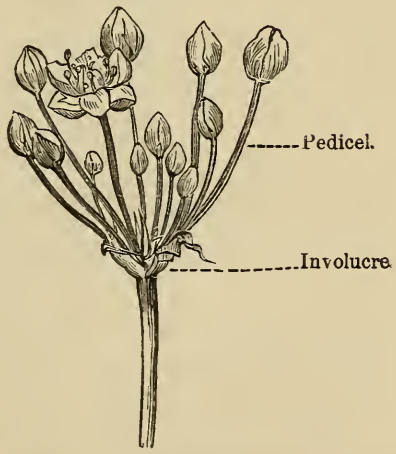


Fig. 135.



EXERCISE XXV.

Attitude of Inflorescence.

When a flower or a flower-cluster is upright, like Figs. 132 and 133, it is described as *erect*.

When the peduncle bends over, as shown in Fig. 131, it is said to be *nodding*.

When flowers hang down, as in Fig. 136, they are said to be *pendulous*.

Fig. 136.

Pendulous.

Prepare an inflorescence schedule with the two questions shown in schedule ninth. Answer these

questions for each of your specimens. Describe the leaves, as is done for Fig. 136, and then give a stem-description by answering the six questions of the stem-schedule, as you see has been done here.

SCHEDULE NINTH, DESCRIBING FIG. 136.

Parts?	*Peduncle, Flower.*
Attitude?	*Pendulous.*

LEAVES.—Opposite, simple, petiolate, exstipulate, feather-veined, irregularly dentate, ovate-acuminate, green, smooth.

STEM.—Round, slightly bending, reddish brown, smooth, slender, solid, woody.

EXERCISE XXVI.

Varieties of Inflorescence.

HEAD.—A more or less globular cluster of flowers, sessile upon the receptacle, Fig. 137.

SPIKE.—A cluster of flowers, sessile upon a rachis, Fig. 138.

SPA'DIX.—A spike with a thick rachis, and covered around by a single large leaf, or bract, called a *spathe*, Fig. 139.

AMENT, or CATKIN.—A *spike*, with sessile bracts among its flowers. It grows on trees and shrubs, and falls off after a while, Fig. 140.

The RACEME is a flower-cluster, where the flowers

Fig. 137.

Head.

Fig. 138.

Spike.

Fig. 139.

Spadix.

Fig. 140.

Catkin.

Fig. 141.

Raceme.

Fig. 142.

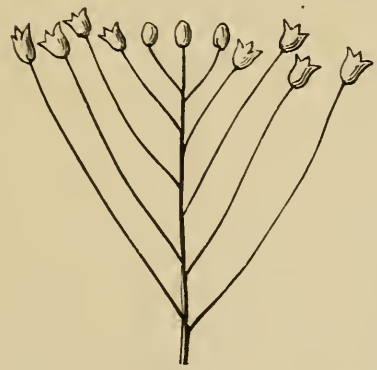
Glomerule.

grow upon pedicels of about equal length along the rachis, Fig. 141.

A GLOMERULE is formed by nearly sessile clusters of flowers in the axils of opposite leaves, Fig. 142.

The CORYMB is a flower-cluster, with a short rachis, the lower pedicels of which are lengthened, so that the cluster is flat at top, Fig. 143.

FIG 143.



Corymb.

FIG. 144.

Umbel.

AN UMBEL has no rachis, and the pedicels are of nearly equal length, Fig. 144.

A COMPOUND RACEME, or PANICLE, has a long rachis, and the flowers grow upon branches of the pedicels. When such a cluster is thick and cone-shaped, it is called a *Thyrse*, Fig. 145.

A COMPOUND CORYMB is a corymb with the flowers growing upon branches of the pedicels, Fig. 146.

A COMPOUND UMBEL has a second umbel, or umbellet, upon each pedicel, Fig. 147.

Most of the clusters pictured in this exercise are represented as without bracts, that differences in their modes of branching may be more easily compared. The pictures represent certain styles of flowering, and each

of these styles varies very much in nature. You will find umbels, panicles, corymbs, etc., very unlike each other. Great differences among the clusters of a va-

Fig. 145.

Compound Raceme.

Fig. 146.

Compound Corymb.

riety may be occasioned by the presence or absence of bracts, by their forms and colors, by the length, stiffness, and ever-varying positions of peduncles and

Fig. 147.

Compound Umbel.

pedicels, as well as by differences in the form of receptacles. The various sorts sometimes run together in many different ways. You may find a flower-cluster resembling two different varieties so much

that you will have to combine the names of the two in order to name it properly; as, for instance, a corymbose-panicle, a panicle of heads, or a spicose-

Fig. 148.

umbel. When you can not name the variety, say so, and keep the instance in mind until you understand it. Can you name the varieties of inflorescence pictured upon the charts?

SCHEDULE TENTH, DESCRIBING FIG. 148.

Parts?	*Peduncle, Bracts, Rachis, Pedicels, Flowers.*
Attitude?	*Erect.*
Variety?	*Raceme.*

LEAVES.—Alternate, simple, sessile, exstipulate, feather-veined, serrate, oval-acute.

STEM.—Erect, round, herbaceous.

ROOT.—Fibrous.

There are some things about the inflorescence, easily understood and described, that have not been named in the schedule, and, that they may be noted in future descriptions, we call attention to them here.

When many flowers are crowded upon a rachis, or receptacle, the cluster is said to be *dense;* but when they are few and scattering, it is said to be *loose.*

The bracts of a cluster may be very numerous, or they may present peculiarities that a child can easily describe—such, for instance, as relate to shape or color—or they may form an involucre at the base of the cluster, and these points might well be included in a description.

CHAPTER V.

THE FLOWER.

EXERCISE XXVII.

Parts of the Flower.

The study of forms in the flower will give you more to observe than all the other parts of the plant put together. There are a good many different parts that go to the making of a complete flower. And the names of all these parts must be learned before you can understand what is said about them, or write down what you find out yourself. This, then, will be your first business. If you begin at the outside of a flower (see the one shown, pulled apart, in Fig. 149), you come first upon the calyx. Next within the calyx is the corolla. Inside of that are the stamens, and in the center of the flower you find the pistil.

The Recep'tacle is the top of the peduncle, more or less swollen, from which the flower grows.

The Ca'lyx is the outer circle of green flower-leaves.

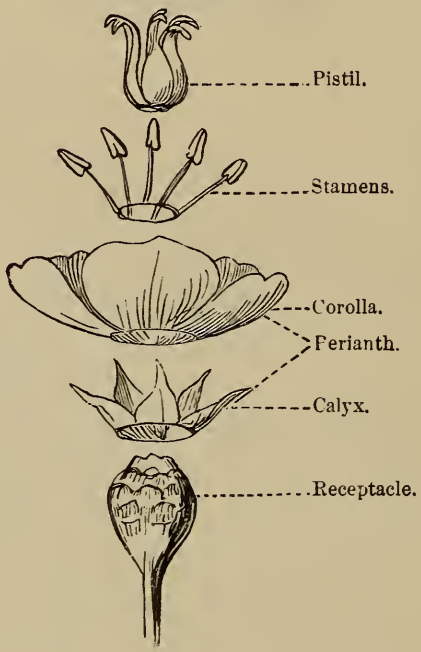
The Corol'la is the inner circle of delicately-colored flower-leaves.

The word Per'ianth is a name given to both circles of flower-leaves when they are so nearly alike as not to be separable into calyx and corolla. See Fig. 155.

Sta'mens.—Slender, thread-like parts next inside the corolla.

Pis'til.—The central part of the flower inside the stamens.

Fig. 149.



When there is but one whorl of flower-leaves, whatever its color, it is called a calyx.

What is the receptacle of a flower? What is the calyx? What is the corolla? What is the part in the center of the flower called? What surrounds it?

Look at the picture of half of a large flower in the upper left-hand corner of Chart One. It is a buttercup, but the picture is much larger than a real flower, and all its parts can be plainly seen. Point out the receptacle. Point out and give the names of the other parts of this flower.

Gather as many flowers as you can find, and point out and name the parts that compose them. Look out for flowers that have a perianth instead of calyx and corolla.

EXERCISE XXVIII.

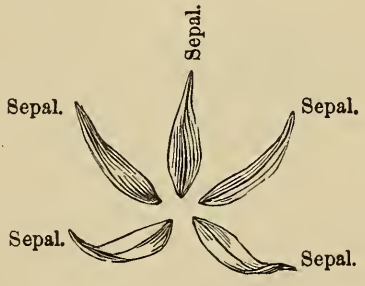
Parts of the Calyx and Corolla.

Each of the parts of the flower shown in Fig. 149 is called a floral whorl. A whorl of little leaves makes up the calyx. Another whorl of delicate leaves forms the corolla. The stamens are in the form of a whorl, and so are the parts of the pistil. The parts of these whorls have their names, and the very best way to learn all these names, so as to know exactly what they stand for, is to write them as you have to do in using the flower-schedule. Prof. Henslow, the author of this schedule. made it in the shape of four columns, and the use of each column was written above it. The first one is for the names of the chief parts of flowers, and is headed Names. As there are four of these

Fig. 150.

Calyx.

Fig. 151.

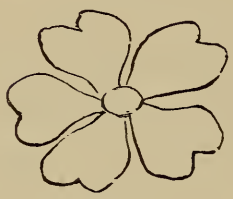


chief parts, this column is divided into four parts. The upper part is for the calyx, and has the word "ca-

lyx" written in it, as seen in schedule eighth. The next division of this column is for the corolla, as you see. The divisions for stamens and pistil will be given when we have learned more about the naming of the calyx and corolla.

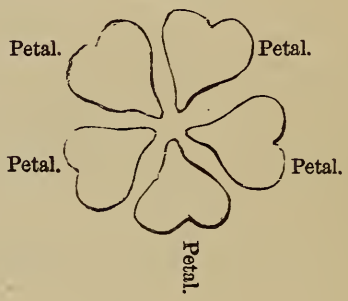
The leaves of the calyx, Fig. 150, are pulled apart and named in Fig. 151, and you are told what a sepal

Fig. 152.



Corolla.

Fig. 153.



is. The same is done for the corolla in Figs. 152 and 153. Schedules eight and nine give the names of these parts in the two flowers they describe.

Fig. 154.

Fig. 155.

Se'pal.—One of the leaves of the calyx.
Pet'al.—A leaf of the corolla.

The second column of the flower schedule, you see, is headed Number, and contains the number of parts that form the calyx and corolla.

Begin in this way at once to write descriptions of the calyx and corolla of each of your flowers.

SCHEDULE EIGHTH, DESCRIBING FIG. 154.

Names of Parts.	No.	
Calyx?		
Sepals.	*5.*	
Corolla?		
Petals.	*5.*	

SCHEDULE NINTH, DESCRIBING FIG. 155.

Names of Parts.	No.	
Perianth?		
Leaves.	*6.*	

EXERCISE XXIX.

Kinds of Calyx.

HAVING used schedules till the names of the parts that compose the calyx, corolla, and perianth are well learned, you are ready to begin the use of the third column of the schedule.

This column of Prof. Henslow's schedule is for writing down whether or not the parts of a floral whorl are grown together. This is very important; and when you have found out, there is a very long word used by botanists to express the fact. For in-

stance, a calyx like that shown in Fig. 156 has its sepals separate. They are not grown together; but, instead of using these words to express the fact, botanists say they are *polysepalous*, which means the same thing. Again, if the sepals are grown together, however slightly, as in Fig. 157, they are said to be *gamosepalous*, which means the same thing. See schedule tenth.

FIG. 156.

Polysepalous Calyx.

FIG. 157.

Gamosepalous Calyx.

A POLYSEP'ALOUS CALYX has its sepals distinct from each other, so that each one can be pulled off separately.

A GAMOSEP'ALOUS CALYX has its sepals more or less grown together by their edges, so that, if you pull one, the whole calyx comes off.

EXERCISE XXX.

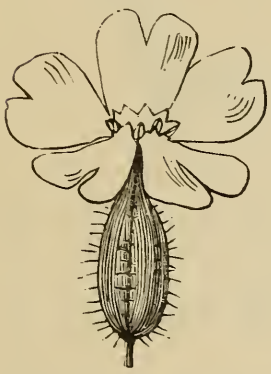
THE study of corollas brings forward a good many new words to describe the new forms. You must learn these words in the same way that you have learned what has gone before. Take time to study all the flowers you can find. Compare their corollas with the pictures and definitions that follow, and when you

have found one which is, definition and all, like the corolla you are studying, use its name in the schedule description.

Kinds of Corolla and Perianth.

A Polypet′alous Corolla has its petals distinct and separate from each other, so that each one can be pulled off without disturbing the others, Fig. 158.

Fig. 158.



Polypetalous Corolla.

Fig. 159.

Gamopetalous Corolla.

A Gamopet′alous Corolla has its petals more or less grown together by their edges, so that if you pull one the whole corolla comes off, Fig. 159.

A Regular Calyx, Corolla, or Perianth, has all its parts of the same size and shape, Fig. 160.

An Irregular Calyx, Corolla, or Perianth, has some of its parts unlike the others in size or form, Fig. 161.

Observe first whether the sepals of a calyx, the petals of a corolla, or the leaves of a perianth, are grown together or not. Sometimes they are so slightly united that you must look closely to find it out. Be cautious about calling a corolla polypetalous until

Fig. 160.

Regular Gamopetalous Corolla.

Fig. 161.

Irregular Gamopetalous Corolla.

you have looked at a good many different specimens of it. Do not guess.

You can count the petals of gamopetalous corollas by their marks of union.

Schedule Tenth, describing Fig. 159.

Names of Parts.	No.	Description.
Calyx ?		*Gamosepalous, regular.*
Sepals.	*4*	
Corolla ?		*Gamopetalous, regular.*
Petals.	*4.*	

A Polyphyl'lous Perianth has its leaves entirely distinct and separate from each other.

A Gamophyl'lous Perianth has its leaves more or less grown together by their edges.

In the schedule will be seen a space where the forms of sepals and petals should be recorded in the same terms used to describe leaves.

EXERCISE XXXI.

Stamens and Pistil.

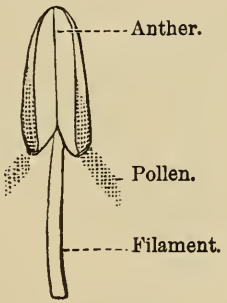
You must now observe the parts of the stamens and pistil, and learn their names.

Parts of Stamens.

Fil'ament.—The stem-like part of a stamen, Fig. 162.

An'ther.—The thickened oblong head of a filament.

Fig. 162.



Pol'len.—The dust, or powder, seen upon the anther.

To study the stamens and pistil of flowers, select

large, well-developed specimens. Meadow-lilies and many other common flowers have large stamens, and all the parts of their pistil can be plainly seen.

Parts of the Pistil.

O'VARY.—The lowest part of the pistil, containing the seeds, Figs. 163, 164, 165.

STYLE.—The slender, stem-like part of the pistil next above the ovary.

FIG. 163.

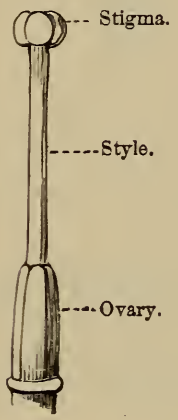


FIG. 164.

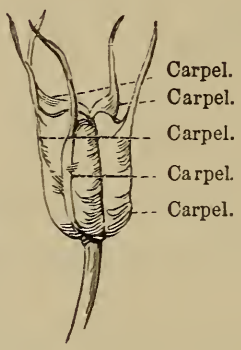


FIG. 165.

Four Carpels.

STIG'MA.—The top of the pistil.

CAR'PEL.—One of the divisions, or cells, of the ovary.

It is in old, withered flowers that you should look for the carpels. The ovary continues to grow after the flower has disappeared, and reaches perfection in the ripened fruit.

Point out and name the parts of the magnified stamens shown upon the chart. Can you find the ripened carpels of the pistils of flowers on the chart? Point out and name the parts of the stamens and pistil of the flowers you have collected.

EXERCISE XXXII.

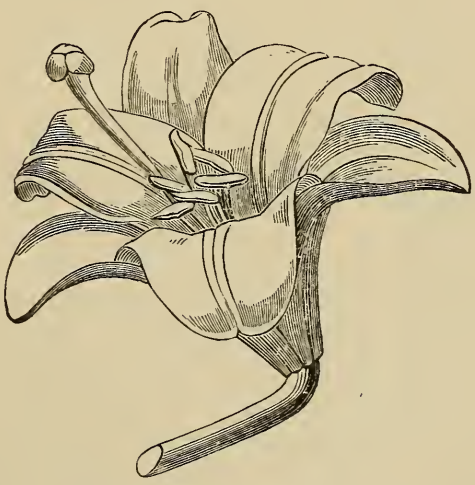
How to describe Stamens and Pistils.

THE way to get familiar with the names used in the last exercise is to use them over and over again in describing flowers.

Schedule eleventh has added to it the new question, Stamens? Write underneath it the name of the parts that compose a stamen of your flower. Count the number of stamens, and write it down, unless they are too numerous, when you will use the character ∞, signifying many. Write "free," when they are not grown together; and "coherent," when they are grown together.

When the filament is absent, write "sessile" after anther. To describe the filaments, observe whether they are long or short, slender or thick, flat or round, distinct or grown together.

FIG. 166.



Observe whether the anthers are one-lobed or two-lobed, that is, whether they are in two parts or

pieces; and note also whether they are oblong, round, curved, straight, large or small, longer or shorter than the filaments, distinct or grown together.

The question Pistil? is also added to the schedule, and is to be answered in the same way as the questions Perianth? and Stamens? First write the name of its parts underneath, and then find out, if you can, the number of carpels that compose the ovary. It is sometimes quite difficult to do this, but it is well always to make the effort. When the number of car-

Fig. 167.

Fig. 168.

pels can not be made out directly, count the styles, and, if these are grown smoothly together, then count the lobes of the stigma. It is very seldom that this part of the pistil is so coherent that the lines of union are invisible. You can often, in this way, find out the number of carpels in a pistil, when every other means fails.

SCHEDULE ELEVENTH, DESCRIBING FIGS. 166-168.

Names of Parts.	No.	Description.
Perianth?		*Polyphyllous, regular*
Leaves.	*6.*	
Stamens?	*6*	*Free.*
Filament.		*Slender.*
Anther.		*Oblong.*
Pistil?		
Carpels.	*3.*	
Style.		*A single column.*
Stigma.		*Three-lobed.*

EXERCISE XXXIII.

Kinds of Polypetalous Corollas, Regular and Irregular.

BEFORE you begin with this exercise, be sure to have all the different kinds of flowers that you can

FIG. 169.

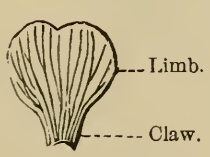
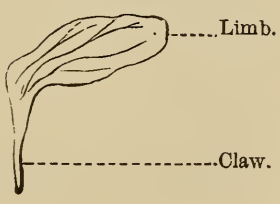


FIG. 170.



get. First of all, observe the parts of petals. They are pointed out and named in Figs. 169 and 170.

Limb.—The upper, and usually the broadest and thinnest, part of a petal.

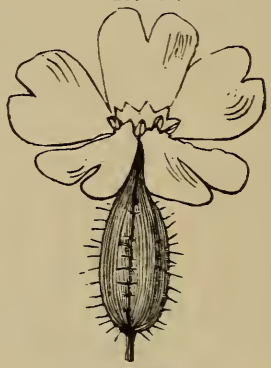
Claw.—The lower part of a petal, by which it is joined to the receptacle.

The kinds of regular polypetalous corollas are shown and named in the following pictures:

Fig. 171.

Cruciferous.

Fig. 172.



Caryophyllaceous.

A Crucif'erous Corolla has four petals growing in the shape of a cross, Fig. 171.

A Caryophylla'ceous Corolla has five petals,

Fig. 173.

Rosaceous.

Fig. 174.

Liliaceous.

having each a long, slender claw and a spreading limb, Fig. 172.

A Rosa'ceous Corolla has five petals, with spreading limb and short claw, Fig. 173.

A Lilia'ceous Perianth has six leaves, bending away, as seen in Fig. 174.

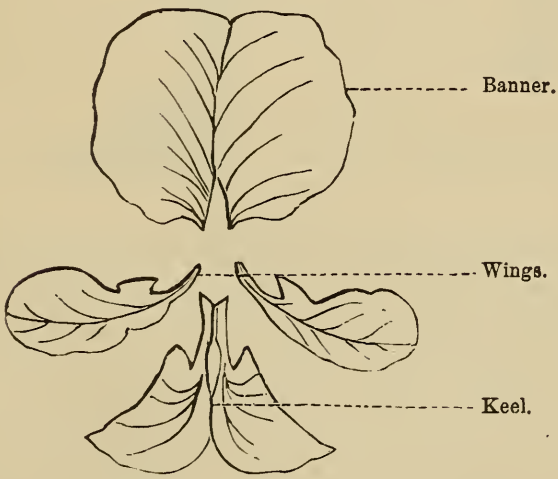
Fig. 175.

Papilionaceous Corolla.

Fig. 176.

Some kinds of irregular polypetalous corollas have a special name. Fig. 175 is an example.

Fig. 177.



The Papiliona'ceous Corolla has five petals, arranged like Fig. 177. The one nearest the stem (the

upper, Fig. 175) is called the *banner;* the two side ones are called *wings*, and the lower ones the *keel.*

Fig. 178.

Fig. 179.

Learn to distinguish the banner, wings, and keel of papilionaceous corollas, and note the differences of their forms in different kinds of flowers. You can write such observations as these upon the back of the schedule. Do not hurry along to new lessons while the forms of corollas shown in this and the following exercises are strange to you. Gather all sorts of flowers and describe them carefully.

There are many other varieties of polypetalous

irregular corollas, which are described generally as *anomalous*. There is an interesting tribe of plants

FIG. 180.

known as orchids, which present many anomalous forms of corolla; Fig. 179 is an example, Fig. 180 being a separate flower from the same plant. Anomalous flowers should be further described as polypetalous or gamopetalous, for they occur among both these forms.

EXERCISE XXXIV.

Kinds of Gamopetalous Corollas, Regular and Irregular.

BEFORE you go any further with your study of the forms of corollas, you must look more closely at the PARTS of such ones as are shown in Figs. 181 and 182.

TUBE.—That part of the corolla, whether long or short, in which the petals are united together, as shown in the figures.

LIMB, OR BORDER.—The upper part of the corolla, where the petals are not united.

THROAT.—The opening into the tube.

Corolla-Tubes may be long or short, slender or swollen, tapering or cylindrical, or with a pouch, or sack, on one side.

Fig. 181.

Fig. 182.

The Limb may be narrow or broad, erect or spreading; and

The Throat may be open or constricted, hairy or smooth.

Note these features in describing gamopetalous corollas.

The following are the principal kinds of regular gamopetalous corollas:

Tu'bular.—A tubular corolla is one in which the tube spreads little or none at the border. Fig. 183.

Fig. 183.

Tubular.

Fig. 184.

Urceolate.

Fig. 185.

Rotate.

Ur'ceolate.—A corolla is urceolate when the tube is swollen in the middle, with a narrow opening like an urn, as in Fig. 184.

Ro'tate, or Wheel-shaped Corollas have a short tube, and flat, spreading border. Fig. 185.

Fun'nel-form.—When the corolla-tube is small below, and enlarges gradually to the border, as in Fig. 186.

Sal'ver-form.—When the long, slender tube of a

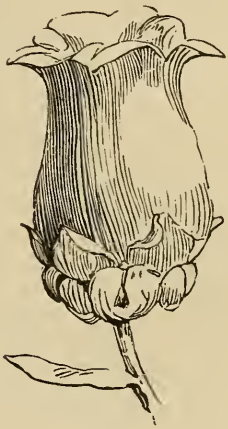
Fig. 186.

Funnel-form.

Fig. 187.

Salver-form.

Fig. 188.



Campanulate.

corolla ends abruptly in a flat, spreading border, as seen in Fig. 187.

Campan'ulate.—Bell-shaped corollas are said to be campanulate. Fig. 188.

Irregular gamopetalous corollas are named as follows:

La'biate.—In labiate corollas the limb has the appearance of lips. Labiate corollas are of two kinds, personate and ringent, as shown in Figs. 189 and 190.

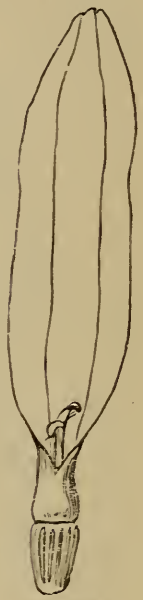
Per'sonate.—With the throat closed.

Rin'gent.—With the throat open.

A Lig'ulate, or strap-shaped, corolla, is one which appears as if it were formed by the splitting of the tube on one side. Fig. 191.

Anom'alous.—All other irregular gamopetalous corollas, as Figs. 192 and 193, are called *anomalous*.

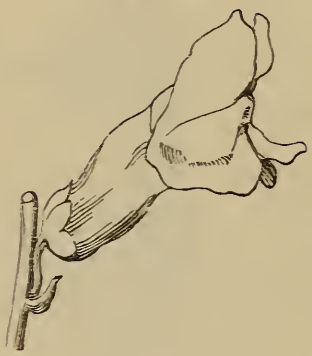
Fig. 191.



Ligulate.

Labiate Corollas.

Fig. 189.



Personate.

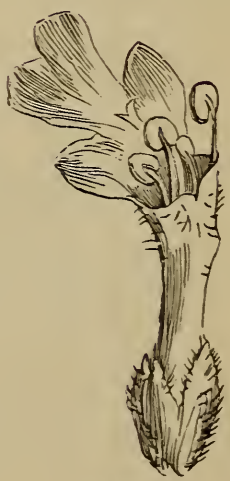
Fig. 190.

Ringent.

Fig. 192.

Anomalous.

Fig. 193.



Anomalous.

In describing corollas, the terms cruciferous, liliaceous, tubular, etc., may now be used in place of polypetalous, gamopetalous, regular and irregular, as the new terms include these characters, along with others, more limited and special. To say, for example, that a corolla is *cruciferous*, is to say that it is polypetalous and regular, and also to state the number and position of its petals. To say that a corolla is *strap-shaped*, implies that it is gamopetalous and irregular, while giving its special form.

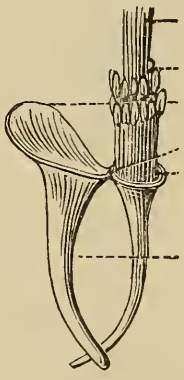
EXERCISE XXXV.

Crowns, Spurs, and Nectaries.

The Corona, or Crown, is a scale-like structure, Figs. 194, 198, on the inner surface of corollas, at the summit of the claw, or tube.

Fig. 194.

Fig. 195.



A Spur is a tubular prolongation of a petal or sepal. Figs. 195 and 199.

Fig. 196.

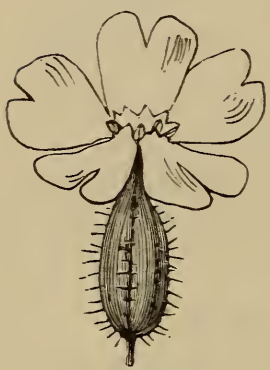
Nectary.

Fig. 197.

Nectary.

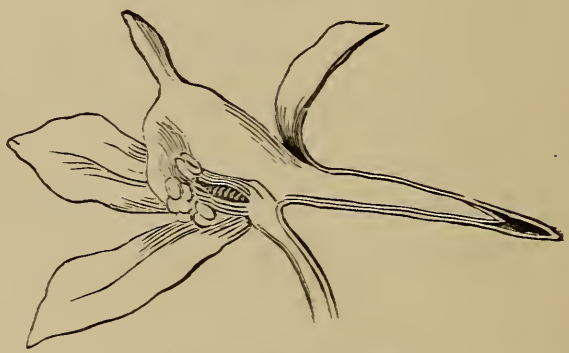
A Nectary is a little gland on the claw of a petal that secretes a sugary liquid. In Fig. 196 these

Fig. 198.



Corolla with Crown.

Fig. 199.



Spurred Calyx and Corolla.

glands are naked, while in Fig. 197 the little gland is covered by a scale.

EXERCISE XXXVI.

Symmetry of Flowers.

Gather a variety of flowers, and before you begin their study look carefully at the pictures and definitions of this exercise.

Count the sepals shown in Fig. 200. Count the

petals. Count the stamens. Observe the two-lobed stigma of the pistil. Has each of the floral whorls the same number of parts? Then it is a symmetrical

Fig. 200.

Binary Symmetry.

Fig. 201.

flower. And it would still be symmetrical if the number of sepals, or petals, or stamens, or carpels, were twice as many, three times as many, and so on.

Count the parts in the floral whorls of Fig. 201.

Fig. 202.

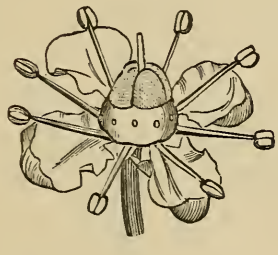


Fig. 203.

It has three sepals, you say, and three petals; but there are six stamens and six carpels. Is this flower symmetrical?

A symmetrical flower is one having the same number of parts in each of its whorls, or, if not the same, then twice as many, three times as many, or any multiple of the prevailing number.

Does Fig. 202 represent a symmetrical flower? Are the parts symmetrical in Fig. 203?

When the parts of a flower are arranged in twos, or multiples of two, the symmetry is said to be *dimerous* or *binary*. Fig. 200.

When the parts of the floral whorls are in threes, or multiples of three, the symmetry is *trimerous* or *ternary*. Fig. 201.

When the parts are in fours, the symmetry is *tetramerous* or *quaternary*. Fig. 202.

When the parts are in fives, the symmetry is *pentamerous* or *quinary*.

If you have the botanical charts, look at the magnified flowers represented on them, and point out the symmetrical ones, naming the kind of symmetry they exhibit. Then examine your living specimens. These will, of course, vary with the season. We will suppose, for example, that you have the pea, morning-glory, violet, portulaca, buttercup, Saint-John's-wort, hollyhock, potato-blossom, evening primrose, lily, etc. Decide which are symmetrical and which are unsymmetrical, placing the two kinds apart. Re-examine the symmetrical ones, and tell which have binary symmetry, which ternary, which quaternary, and which quinary.

EXERCISE XXXVII.

Complete and Incomplete Flowers.

The collection of flowers that in the previous exercise were separated into symmetrical and unsymmetrical ones, may now be rearranged, separating the

complete from the incomplete, according to the following definitions:

Complete Flowers consist of calyx, corolla, stamens, and pistil (Fig. 204).

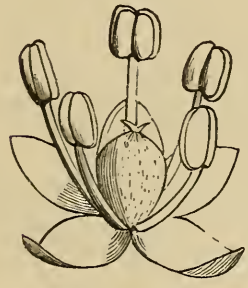
Fig. 204.

Complete Flower.

Incomplete Flowers have one or more of the floral whorls absent (Figs. 205 and 206).

Find upon the charts examples of complete and incomplete flowers.

Fig. 205.



Incomplete Flower.

Fig. 206.

Incomplete Flower.

If any of the flowers present strange appearances, let them pass; by-and-by, after further study, you can put them where they belong.

EXERCISE XXXVIII.

Essential Organs and Protecting Organs.

THE chief purpose of the flower is the production of seed; but, to this end, some of its parts are more necessary than others: for example, the action of both stamens and pistil is needed in the formation of seeds, while they are often produced without the presence of either calyx or corolla. The stamens and pistil are therefore called the *essential organs* of flowers; and, as the calyx and corolla cover and nourish these, they have been called the *protecting organs.*

Point out upon the charts the protecting organs of flowers. Point out the essential organs. Do you find both sets in all the flowers represented?

Examine your collection of flowers, and point out in each specimen the essential organs and the protecting organs.

EXERCISE XXXIX.

Dichlamyd'eous, Monochlamyd'eous, and Achlamyd'eous Flowers.

WHEN the protecting organs, calyx and corolla, are present in a flower, it is said to be *dichlamydeous* (Fig. 207).

When there is but one whorl of protecting organs, whatever its color or texture, it is called a *calyx*, and the flower is *monochlamydeous* (Figs. 208 and 209).

A flower destitute of protecting organs is *achlamydeous* (Fig. 210).

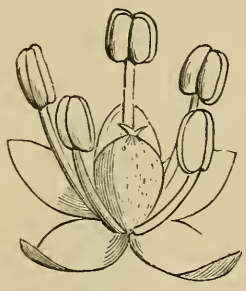
Achlamydeous flowers are said to be *naked.*

Fig. 207.

Dichlamydeous Flower.

After observing the pictures, and reading the definitions of this exercise, you may find upon the charts all the pictures of dichlamydeous flowers; of mono-

Fig. 208.

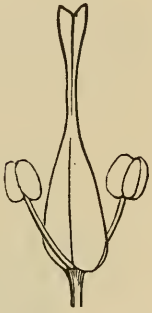


Monochlamydeous Flower.

Fig. 209.

Monochlamydeous Flower.

Fig. 210.



Achlamydeous Flower.

chlamydeous flowers; of achlamydeous, or naked flowers. Then look over your living specimens again, putting the dichlamydeous ones by themselves; the monochlamydeous; the achlamydeous. Pay no attention to the doubtful instances; there will be fewer and fewer of these as your observations proceed.

EXERCISE XL.

Perfect, Imperfect, and Neutral Flowers.

Pictures, illustrating this and the following exercise, may be found upon the charts. Living specimens of the kinds described will, perhaps, not often occur in the collections made for study. But if you keep a constant lookout for them you will be likely to get them before a long time.

A Perfect Flower has both the essential organs (Fig. 211).

An Imperfect, or Diclinous, flower has but one of the essential organs. If it have stamens only, it is said to be *staminate* (Fig. 212); if pistil only, it is said to be *pistillate* (Fig. 213).

Neutral Flowers are destitute of both stamens and pistil (Fig. 214).

When imperfect flowers are staminate (Fig. 212), they are said to be *sterile*, because they never produce

Fig. 211.

A Perfect Flower.

Fig. 212.

Fig. 213.

Imperfect Flowers.

seed. Sometimes they are spoken of as *male* flowers. When imperfect flowers are pistillate (Fig. 213), they

are said to be *fertile*, because they bear seed. They are also called *female* flowers.

Perfect flowers, like Fig. 211, are said to be *hermaphrodite*, because both sexes are united in the same individual.

Fig. 214.

A Neutral Flower.

Observe well and remember the following characters; they occur very often in writing about plants:

A perfect flower is indicated thus, ☿.

A staminate, sterile, or male flower, thus, ♂.

A pistillate, fertile, or female flower, thus, ♀.

Look over the charts for examples of perfect, imperfect, and neutral flowers.

EXERCISE XLI.

Monœcious, Diœcious, and Polygamous Plants.

When both staminate and pistillate flowers grow upon the same plant (Fig. 215), it is said to be *monœcious*.

Fig. 215.

A Monœcious Plant.

Fig. 216.

Pistillate Flower, from Catkin (Fig. 217).

Fig. 217.

Female Catkin of a Dicœcious Plant.

When staminate and pistillate flowers grow upon separate plants, such plants are said to be *diœcious*. Fig. 216 represents a pistillate flower from the female catkin (Fig. 217). Fig. 219 represents a staminate

Fig. 218.

Male Catkin of a Diœcious Plant.

Fig. 219.

Staminate Flower, from Catkin (Fig. 218).

flower from the male catkin (Fig. 218). These catkins grow upon different trees; so the willow from which they were taken is *diœcious*.

When staminate, pistillate, and perfect flowers are all found upon the same plant, it is *polygamous*.

Point out upon the charts examples of monœcious, diœcious, and polygamous plants.

Let the pupil answer the following questions concerning each flower of his collection: Is your flower symmetrical or unsymmetrical? Is it complete or incomplete? Is it dichlamydeous, monochlamydeous, or achlamydeous? Is it perfect or imperfect? Did it grow upon a monœcious, diœcious, or polygamous plant?

CHAPTER VI.

THE SEED.

EXERCISE XLII.

Parts of the Seed.

We now pass to another class of observations, in which, besides noting new parts of plants, you will also have to watch the changes which take place in those parts.

Prepare for the study of seeds by planting all the kinds you can get that are large enough for easy examination.

The seeds of the pumpkin, squash, four-o'clock, bean, pea, apple, Indian corn, oats, and barley, are good examples for the purpose. Plant two or three dozens of each sort, one inch deep, in a box of soil or sawdust, which must be kept warm and moist. Put the different kinds in rows by themselves, and mark each row, so that, when you want any particular one, you can get it without mistake.*

You should also be provided with a blank-book in which to write the results of study. Such a note-book is easily made by twice folding enough sheet-paper to allow a page to each kind of seed you have planted.

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* If pupils can not get time to prepare for these exercises out of school-hours, they should be encouraged to do it during school-time.

Write the name of a kind, as pea, oat, etc., on each successive page, till all are inserted.

When your seeds have soaked for a day or two in the wet earth, take a bean from the box and compare it with one that has not been planted.

How has it changed in appearance?

Cut it in two and see whether, like a piece of chalk, it looks alike outside and inside, or whether the parts are unlike.

Has it a skin or shell that you can loosen?

Take a second bean from the box, cut carefully around it, and try to peel off the outer part.

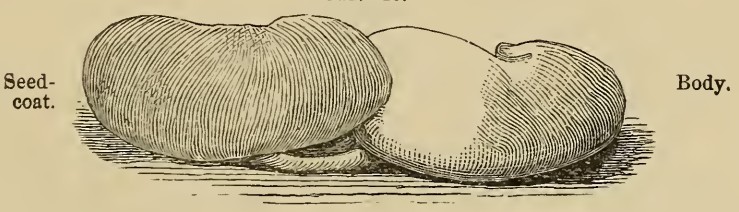
Seed-coat, or Integ'ument.—The skin or shell around the outside of a seed.

Body, Kernel, or Nu'cleus. — The substance within the seed-coat.

Compare your specimen with Fig. 220.

Can you separate the seed-coat from the body of the bean as it is seen to be separated in the picture?

Fig. 220.



Now take a pea from your box and see if it is made up of parts.

Has it a seed-coat? Is there a kernel or body within the seed-coat?

Try a pumpkin-seed. Compare the coat of a pumpkin-seed with that of the pea or bean.

Are they alike in thickness? in hardness? in color? in transparency? Name all the differences you see between them.

In the same way, take up and examine, one after another, some seeds from each of the rows. Find their parts, and compare the parts of one kind of seed with those of another kind.

If you are not able at first readily to separate a seed into distinct portions, do not hastily conclude that it is without them. Let it lie in its warm, wet bed a while longer, and then try again.*

Now write in your note-book just what you have discovered about the parts of seeds. For instance: if at the top of the first page you have written *bean* on the line beneath you now write the question, Parts? and the answer which you have found to this question—thus:

Parts? Seed-coat. Body. Coat, thin, skinny;

or, on the page devoted to the apple-seed, you write:

Parts? Seed coat. Body. Coat, woody, brown, thin;

or, on the page for pumpkin-seed, you say:

Parts? Seed-coat. Body. Coat, shelly, thick, limber.

---

*Much that is important in their experiments children will fail to see, and they will fancy they see much that does not exist. Their omissions, misinterpretations, and difficulties can be dealt with in many ways, but a desire on the part of the teacher for nicety of experiment and accuracy of statement should never lead to discouraging criticism. To keep the child happily busy with his growing plants is the main thing, and all degrees of awkwardness and imperfection in childish performance should be tolerated.

Write on all the pages of your note-book in this way, and keep it at hand for reference.

EXERCISE XLIII.

Parts of the Body, or Kernel.

When you have carefully examined all the seeds you planted to find the parts that make them up, you will be ready to study one of these by itself. After taking off the skin or coat of a seed, look closely at the body of it. Begin with a well-soaked seed of Indian corn.

Compare it with Fig. 221.

Is your seed narrower at one end than the other?

Fig. 221.

Are the two sides of it alike? Is there a little pointed or rounded figure to be seen on one side?

Remove the skin and look carefully at the figured side of your specimen. Can you see a thick, lumpy body like the one marked *a* in the picture?

Try, with a dull knife or the finger-nail, to pry this lump out of its bed. If the seed is soaked to its center, you can easily do this. Look carefully at the hole it leaves. Is not its surface smooth? Do you see any spot where the lump seems to have been

grown to the other part, and to have broken away when you took it out?

Compare the parts you have got with Fig. 222.

Fig. 222.

Albumen. Embryo.

Em'bryo.—The young plant contained in a seed.

Albu'men, En'dosperm.—The material in which the embryo is imbedded.

What names are given to the two parts of the body of a seed of Indian corn?

Which is the embryo in your specimen? Which is the albumen?

Now examine the kernel of a pea or bean. Can you separate this into two parts without breaking it somewhere?

Compare it with Fig. 223.

Fig. 223.

Embryo.

What name is given to the entire kernel? What part, found in the Indian corn, is missing here?

Look at the body of a seed of four-o'clock and see how many and what parts it has. Look also at the body of a pumpkin-seed.

Examine the kernel of each of the kinds of seed you have planted, and observe which consist of embryo alone, and which are part embryo and part albumen.

At the same time, write in your note-book, as before, the results of observation. For example, to the question, Parts of the body? write for Indian corn, *Parts of body? Albumen. Embryo.* For Pea. *Parts of body? Embryo.*

EXERCISE XLIV.

Parts of the Embryo.

TAKE out of the soil a bean which has begun to sprout. Remove the seed-coat, and let the parts of the embryo separate, as seen in Figs. 224 and 225.

FIG. 224.

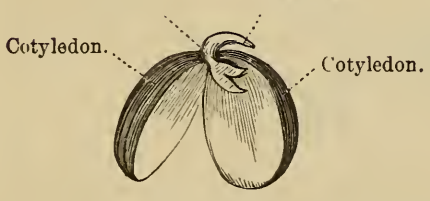
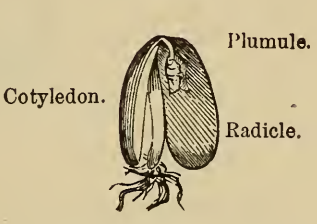


FIG. 225.



COTYLE'DON.—The bulky first leaf or leaves of the embryo—more or less formed in the ripening of the seed.

RAD'ICLE.—The lower end of the embryo, from which the root proceeds.

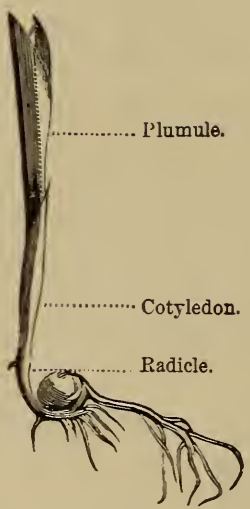
PLU'MULE.—The first—the terminal bud—the upper end of the embryo.

GERMINA'TION.—The beginning of growth in a seed.

Read the names of the parts of the embryo given in Figs. 224 and 225. Look at the definitions of these words. Compare your specimen with the figures, and point out its cotyledons; its radicle; its plumule. Handle your embryo with care, for it breaks easily. Has its radicle begun to put forth roots?

Take from your box a vigorous seed of Indian corn in which the roots have begun to grow, and compare it with Fig. 226.

Fig. 226.



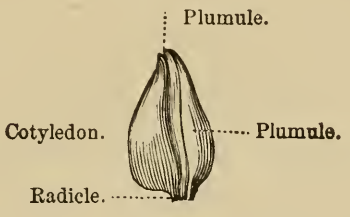
Separate the embryo and albumen, and, if it has grown as much as the one pictured above, you may easily find the cotyledon, the plumule, and the radicle.

When you are sure that you have found the radicle or root-end of your embryo, that you know which part is cotyledon, and which plumule, take another seed of the same kind, but less grown—one where the root-end of the embryo has scarcely begun to swell—and see if you can find the parts.

Fig. 227 represents such an embryo with the parts shown.

Point out and name the parts of the embryo of an apple-seed; of a pumpkin-seed; and of each of your

FIG. 227.



specimens successively, as in former exercises. Which of your seeds has the largest plumule before growth begins? Have you any in which the embryo has at first no plumule at all?

Have you failed to find cotyledons in any embryo looked at? *

As the number of your observations increases, and their character varies, you will see more and more the value of your notes recording them.

To the question of this exercise, Parts of Embryo? you give the answers, as before, from direct observa-

* If these experiments with seeds are made as early as April, in this climate, the children who have made them will be ready for more extended observations when planting in the garden begins. Most garden-seeds are too small to be separated into parts by young children. But, when growth begins, their parts enlarge, and a child, who has before studied larger seeds, will be able to identify the radicle, cotyledons, and plumule, without difficulty. In the kitchen-garden, a universal appendage of country-houses, the sprouting of the radish, onion, beet, parsnip, lettuce, tomato, carrot, cabbage, cucumber, etc., will furnish an excellent continuation of the study of seeds.

tion of the structure of the embryo itself. If some seeds give uncertain appearances, wait till growth has proceeded a little further before you decide about them. By premature judgments you may fill your note-book with errors which you will be compelled to erase.

EXERCISE XLV.

Monocotyledons and Dicotyledons.

A Monocotyled'onous embryo has one cotyledon or seed-leaf (Fig. 228).

Fig. 228.

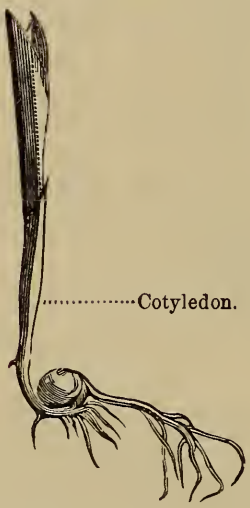
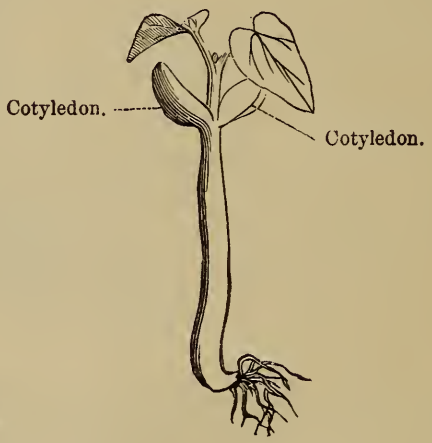


Fig. 229.



A Dicotyled'onous embryo has two cotyledons or seed-leaves (Fig. 229).

These are long, hard words, hard to pronounce, and hard to spell. But they are very necessary words in describing seeds. You can soon learn them.

Go over the seeds you have planted, and point out

the dicotyledons. Show the two thick leaves that were packed within the seed-coat when the seed ripened.

Are any of your seeds monocotyledonous? If so, which?

Figs. 228 and 229 were drawn from plants that had grown a little. When your seeds have also grown a little, compare them one after another with these pictures. Look at your young bean-plant. Find the first node above the cotyledons. How many leaves are growing there? how many at the first node of the corn-stem? how many in each of your growing seeds?

Observe whether the cotyledons in all cases rise into the light and air. Observe whether all cotyledons are shaped alike, and also whether they resemble the true leaves of the plant. Write carefully in your note-book the decision you have made in this exercise about each of your seeds. You will have occasion to refer to it as soon as your plants have put forth perfect full-grown leaves.*

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* A word of caution may not here be amiss. There is danger that the sympathy of teachers with bright and interested pupils will lead them to tell in advance what children can find out for themselves by continued observation. The connection between number of cotyledons and venation is an instance of such temptation. This relation is an impressive one, and prominent in classification; but there is no need of haste in getting to it. By-and-by, when the leaves of his growing plants are well developed, by the aid of his note-book, the pupil might be put in the way of discovery, by asking him to make a list of his monocotyledons, and to give their venation in each case. Let him do the same with his dicotyledons. He will now see a perfect uniformity of relation in a few cases, and will be curious to know if it is everywhere constant. He will thus arrive at the induction by his own observation.

CHAPTER VII.

WOODY PLANTS.

EXERCISE XLVI.

Their Different Kinds.

What do you name all the soft, fragile plants that die down to the ground in winter?* Is there any name for all woody plants? Do you know of any woody plants that are not trees? If so, what do you call them? What is the difference between a young tree and a bush? Between a bush and a shrub?

The following pictures and definitions are given to help you in distinguishing one group of woody plants from another. After carefully looking them over, you should go through the streets and the fields, and whenever you see a woody plant, decide whether it is a tree, shrub, bush, under-shrub, or vine. If you take with you a companion who is interested in the same pursuit, it will be all the better.

Although trees vary much in size, height, and shape, and are often not nearly so tree-like as the one represented by Fig. 230, yet it is not easy to mistake them when full grown. If you are doubtful whether a particular plant is a tree or shrub, remember that, when a full-grown woody plant, less than fifteen feet high, is slender, and perhaps has several stems start-

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* See page 76.

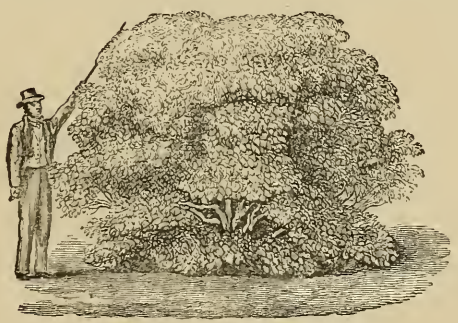
Fig. 230.

Tree.

ing together at or near the ground, as seen in Fig. 231, it is called a SHRUB.

When a full-grown, woody plant, with several stems, is not more than five feet high, it is a BUSH.

Fig. 231.



Shrub.

And when only two or three feet high, whatever its shape, it is called an UNDER-SHRUB. Slender, woody plants that can not hold themselves up, but depend on other objects for support, or trail along the ground, are called VINES.

Besides this separation of woody plants into groups depending upon size and shape, they are again divided into two sorts, called Evergreen and Deciduous.

FIG. 232.

Bush.

EVERGREEN trees, shrubs, etc., keep their foliage all the year round.

DECID'UOUS trees, shrubs, etc., losé their foliage in winter.

So that in winter it is very easy to tell Evergreens from Deciduous plants. Look carefully at the foliage of Evergreens, and see if it resembles that of Deciduous trees.

EXERCISE XLVII.

Parts of a Tree.

TRUNK.—The main stem of a tree.
HEAD.—The branching top of a tree.

Observe the varying lengths of the trunks in the trees about you. Measure the size around their trunks

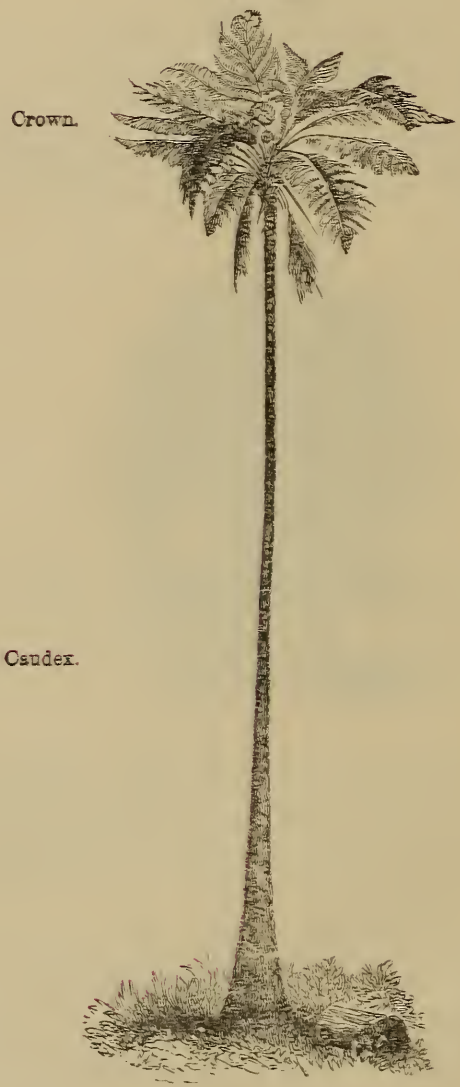
FIG. 233.

at different heights from the ground. Judge as well as you can at what distance from the ground the lowest limb starts from the trunk. Then test your judgment by measuring.

If you call the branches that start from the trunk *primary*, the branches which these put forth may be called *secondary* branches, and those given off next would be *tertiary* branches. In observing the heads of trees, fix your attention upon a primary branch, and see if you can find these divisions. Observe whether the tertiary branches bear still other branches.

Caudex or Stock.—An unbranched trunk produced by the terminal bud alone (Fig. 234).

Fig. 234.



Crown.—The collection of leaves at the top of a caudex.

EXERCISE XLVIII.

Parts of a Trunk.

In living trees there grows each year a ring of wood between the old wood and the bark, and by counting the rings you can tell the age of the tree.

Fig. 235.

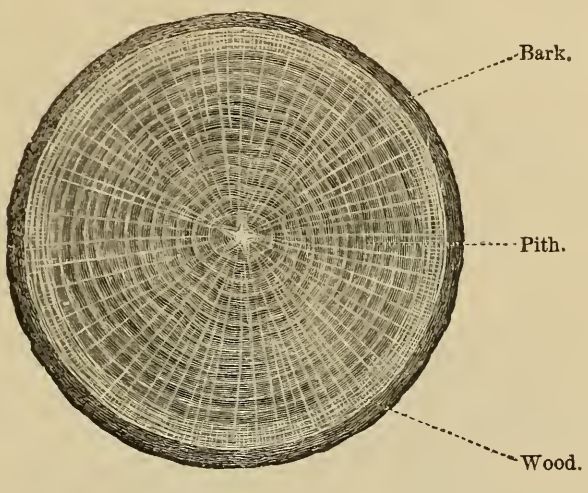


Fig. 235 is a picture of the end of a tree-trunk. A dark and light streak, taken together, represent a yearly ring of wood. Can you tell how many years it was in growing? When you see saw-logs, find out their ages by counting the rings. Observe whether these annual layers are always of the same thickness. Notice whether the wood of a tree, from the center to the circumference, is all of one color.

EXERCISE XLIX.

Kinds of Trunk.

An Indefinite Trunk is one in which the trunk runs through to the top, the terminal bud growing on from year to year with more vigor than any of the branches.

Fig. 236. Fig. 237.

Indefinite Trunk. Definite Trunk.

In a Definite Trunk the stem breaks up into branches, and so disappears, as seen in Fig. 237.

Have apple-trees definite trunks?

Have pine-trees definite or indefinite trunks?

EXERCISE L.

Questions about Trees.

What is the attitude of the trunk in Fig. 238?
What is the form of the head?

FIG. 238.

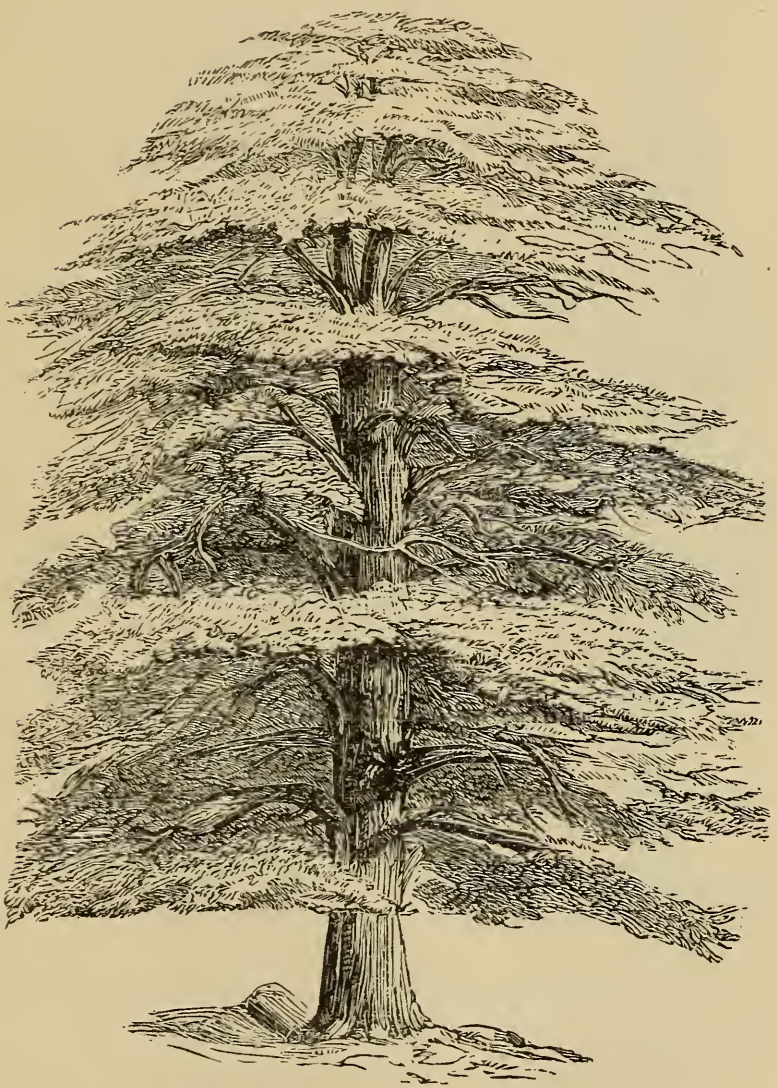


Fig. 239. Fig 240.

Which are the longest—the upper, lower, or middle branches?

What is the direction of the branches?

Are the branches much subdivided?

What proportion of the trunk is below the lowest branches?

Observe whether field-trees and forest-trees differ in this respect.

Answer the same questions in regard to Fig. 239. Fig. 240. Fig. 241. Fig. 242.

Which of these pictures represent definite trunks?

Which indefinite trunks?

If the head of a tree is cone-shaped, which of its branches are longest?

If the head is round, which are longest?

Mention all the differences you see between Figs. 239 and 240.

Which of the pictures shows the most compact head?

Are its branches more subdivided than the others?

When you are somewhat acquainted with the woody plants of your neighborhood, find among them an evergreen and observe it carefully throughout the year. Describe, in your note-book, its appearance in winter. Watch it in spring, and note the changes produced on it by the warm weather. See if any of its foliage ever falls; or if it changes color in the course of the year. Watch for its flowers and fruit. Observe the appearance of its bark, and whether it looks the same in different parts of the tree.

Make and record similar observations upon a deciduous tree. Describe its winter aspect. What time does it put forth leaves? When does it flower? Does its foliage change in color after it is full grown? If so, how? When does it fall? Compare the bark of

Fig. 241.

Fig. 242.

its trunk with that of its twigs.* Compare its bark with that of an evergreen.

In the same way watch the progress of a fruit-tree,

* Twigs.—The remote ends of the branches.

after carefully observing its appearance before growth in the spring begins.

Every bush, shrub, and tree passes each year through a succession of striking changes, which very few people ever observe. Let it be your purpose to see them all.

CHAPTER VIII.

FRUIT.

EXERCISE LI.

What is Fruit?

Pluck from the vine of the pea or bean several pods of different ages, from one still enveloped by the flower, to one that is full grown. Compare the youngest pod you have gathered with Fig. 163. What part of the pistil becomes the pod? Compare it with Fig. 164. How many carpels has the ovary of the bean or pea?

Observe the contents of this pod.

What name is given to these little soft bodies?

Answer.—O′vules.

Compare these ovules with the contents of a full-grown pod. What are these full-grown, ripe bodies called?

What name is given to pod and contents taken together?

Answer.—Fruit.

What is every ovary and its contents?

Answer.—It is fruit. The fruit of a plant is its ripened ovary.

By what words would you distinguish the young from the mature ovary?

Examine all the flowers that are just fading, and look for the ovules in their unripe fruit. Find the

ovules of a young apple. Of an unripe cucumber. Of an unripe tomato. Of any unripe fruit you see growing within reach.

Observe the same plants when the fruit is ripe, and compare the aspect of the seeds with the appearance the ovules presented.

Try to count the carpels in all the ovaries you examine Observe whether they are grown together or not. Count the carpels shown in Fig. 168. Do you see the three white lines passing outward from the center in this picture? Should you judge that the carpels from which this picture was taken were grown together? Search, among plants that are going to seed, for ovaries resembling this one.

EXERCISE LII.

Sutures and Dehiscence.

Look among the ripe and dry pea and bean pods, upon the dry vines, for those that have begun to open. Examine the edges of the separate parts. Do you see something like a joint where the two parts were united? Compare them with Fig. 243.

Dehis'cence.—The opening of a seed-vessel at maturity. See Fig. 243.

Sut'ure.—A seam. The line along which dehiscence occurs, and so permits the escape of the seeds.

Ven'tral Suture.—The inner suture of a carpel. The one looking toward the center of the flower. In Fig. 243, it is the suture along which the ovules are attached.

Dor'sal Suture.—The outer suture. See Fig. 243. What name is given to those joints in ovaries at

Fig. 243.

which they open when the seeds are ripe? How many sutures has a bean-pod? To which suture are the beans attached?

When an ovary opens spontaneously, and thus liberates its seeds, it is called a dehiscent ovary. When it does not so open, it is an indehiscent ovary.

Are there any indehiscent ovaries among the fruits of the garden or farm?

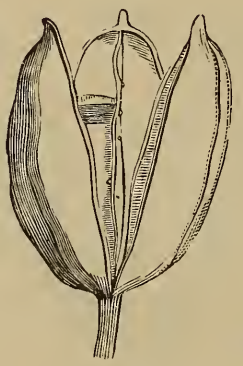
Mention all the dehiscent ovaries you can think of.

Again turn to Fig. 168, and compare it with Fig. 244.

Obtain the ripe fruit of Iris [flower-de-luce], and compare it with the pictures. Is it a dehiscent or indehiscent fruit? Can you find sutures at which the carpels open? What do you call the suture at which the seeds are attached? What do you call the line in the outer wall of each carpel, opposite the ventral suture?

Base.—The bottom of the ovary. The end attached to the peduncle. Figs. 244 and 245.

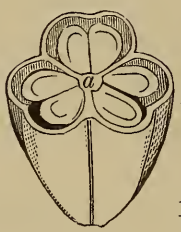
Fig. 244



A′pex.—The top of the ovary. Fig. 244.

Dissip′iments.—The partitions between the cells of syncarpous [carpels united] ovaries. Fig. 245.

Fig. 245.



Pari′etes.—The wall of the ovary. Fig. 245.

Ax′is.—The central part of the ovary where the ventral sutures join together. *a*, Fig. 245.

EXERCISE LIII.

Parts of Carpels.

Valves.—The parts into which carpels separate by dehiscence. Fig. 246.

Placen'ta.—The cord along the ventral suture, to which the ovules are attached. It is the "string" that pulls off in preparing string-beans for cooking. *pl*, Fig. 246.

Find the placenta in full-grown bean and pea-pods. Find it in little ones where you can just see

Fig. 246.

the ovules. Observe the little stem by which the ovules and seeds are attached to the placenta. By what name is it known?

Answer.—It is called the funic'ulus.

QUESTIONS UPON ANY OVARY.

Is it dehiscent or indehiscent?

IF DEHISCENT—

How many carpels compose it?
Are the carpels grown together?
Point out the sutures.
Which is dorsal and which ventral?
Find the valves. The placenta. The funiculus.

IF INDEHISCENT—

Can you count the carpels?
Look for the ovules or seeds.
Point to the funiculus. The placenta.
Point out the base of the ovary. The apex. The axis. The parietes. The dissipiments.

CHAPTER IX.

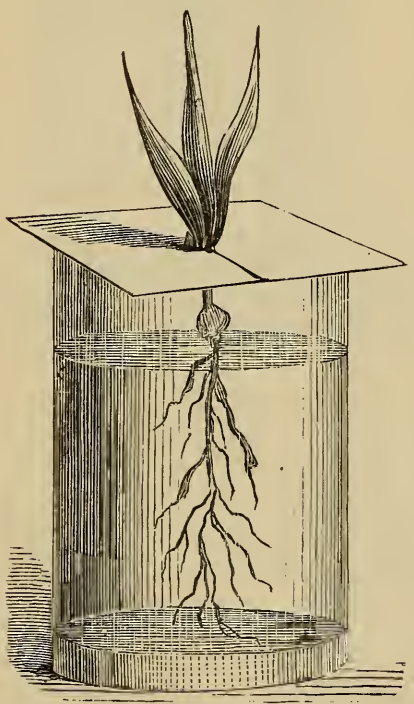
THE ACTIONS OF PLANTS.

EXERCISE LIV.

Root-action and Leaf-action.

Cover a tumbler with a piece of card-board, cut as seen in Fig. 247. Pull up by the roots a young

Fig. 247.

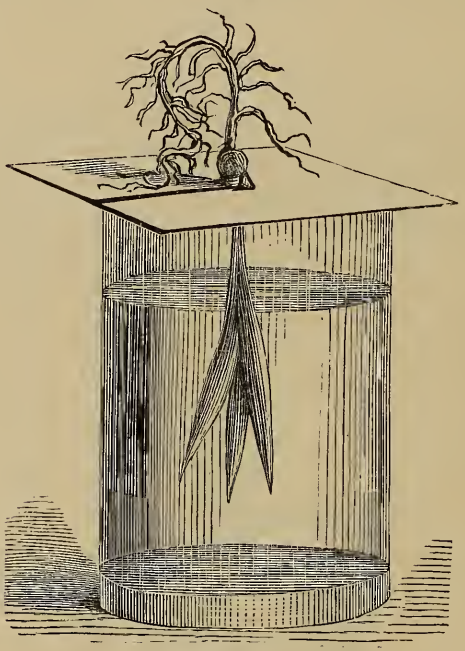


growing plant of any kind, and slip it root downward into the hole made in the center of the card-board.

Pour into the tumbler water enough to cover the roots, and expose the leaves to sunshine.

Into another tumbler of water with a similar cover put a second plant, leaves downward, as shown in Fig. 248, and expose it to sunshine.

Fig. 248.



After a few hours, compare the two plants. How has it fared with the one that had its roots in water? What is the appearance of the other?

Let us now find, if we can, what was going on in the plant that kept up its freshness.

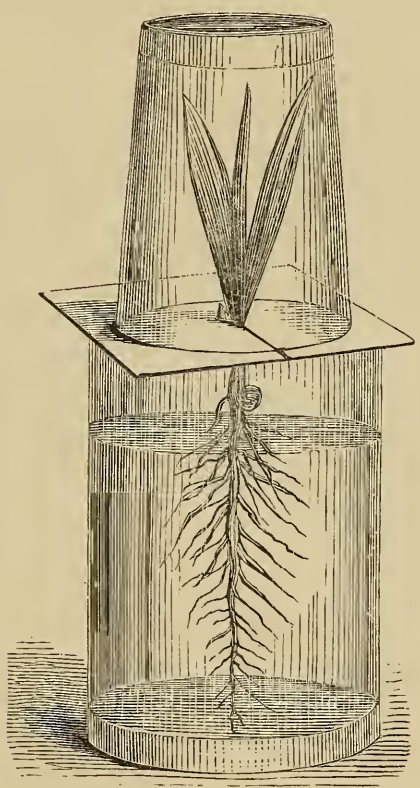
Arrange a glass of water with a cover of slit cardboard as before. Place in it a plant, root downward, and cover the leaves with a glass, as shown in Fig. 249. Let it stand for a time in the sunshine. In a little while look at the inverted tumbler. What do

you see upon its inner surface? Where did it come from? What had the roots to do with it?

Invert a tumbler in this way above the roots of a plant placed as in Fig. 248. Do you, in this case, get moisture on the inside of the inverted tumbler? Can you not make leaves do the work of roots?

Strip a plant of its leaves and place it under a glass as in Fig. 249, with the roots in water. Place

Fig. 249.



it in the sun as before and see if any moisture gathers upon the glass.

What can be done by a plant with leaves, that

can not be done by a plant without leaves? What, then, is one use of leaves?

The action of the root in sucking up water is named ABSORPTION.

The action of leaves in giving off water is called TRANSPIRATION.

The roots absorb. The leaves transpire.

There are two more words that these experiments illustrate. The first of these is the word ORGAN. An organ is any part of a plant or animal that does a particular kind of work different from that done by other parts.

Is the root an organ? What do your legs do that no other part of your body can do? Are they organs? Is your tongue an organ? Are leaves organs?

The other word to be explained is FUNCTION. Organs have functions. The function of an organ is what it does. What is the function of your eye? What is the function of a bird's wings? What function of roots have you discovered by your experiments? What is one of the functions of leaves?

Remember that the particular work any organ does is its FUNCTION.

THE END.

Laboratory Physics

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